TOTAL OUTPUT AND THE PRODUCTIVITY OF LABOUR IN SOVIET INDUSTRY, 1940-1945

by

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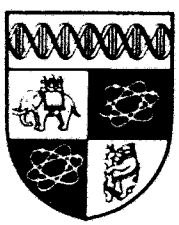

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Abstract

The paper examines official Soviet estimates of the change in total output and output per worker in Soviet industry during World War II. These are shown to have understated wartime industrial performance by a significant margin. New estimates of industrial production, labour inputs and productivity are put forward. The likely contribution to maintenance of total output and labour productivity arising from the rapid structural change in favour of munitions work is also assessed. While output per hour worked in munitions branches of industry grew rapidly, the productivity of labour in civilian branches may have deteriorated before recovering to prewar levels in 1944.

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I

Introduction

Official measures of total output and output per worker in Soviet industry in World War II were first published in full in 1965, in the sixth, summary volume of the *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-1945* (History of the Great Patriotic war of the Soviet Union, 1941-1945).[1] They are shown in Table 1.

They suggest that, in war time, total output of Soviet industry sagged. (The most important reason, of course, was the temporary occupation of large parts of the country by Germany). In spite of rapid expansion of the munitions branch, industrial production as a whole remained below the prewar level until 1944. Then in 1945, in connection with problems of peacetime reconversion, it fell below the prewar level again.

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1 *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-5*, vi (Moscow 1965), 45, 74. However, it can be inferred from remarks by N.A. Voznesensky, *War economy of the USSR in the period of the Patriotic War* (Moscow, 1948), 91, that the index of output per worker had been available for official purposes as far back as 1947.

Output per manual worker, however, grew substantially in wartime industry, the increase in 1944 over the level of 1940 being reported as more than two fifths. According to Voznesensky, the hours worked by manual workers in industry rose by 22 per cent between 1940 and 1942.[2] At first, therefore, the main contribution to increased output per manual worker came from increased hours. But output per hour worked was also rising, and continued to rise after 1942 on the assumption that the increased working hours of 1942 were no more than maintained for the rest of the war. By 1944, when the war effort reached its peak, output per hour worked must on this assumption have been higher than the prewar level by about 16 per cent.

How was output measured? Industrial production as a whole was measured by the gross value of output (GVO, in Russian, *valovaya produktsiya*), output per manual worker by finished or gross output (*vyrabotka*). Here and below I use 'gross output' exclusively for *gross output in the western concept* of value added (net output) plus inputs purchased from other branches. This corresponds to the total revenue (net of intra-branch transactions) received by each branch of the economy, *less* turnover taxes. I use the 'gross value of output', shortened to GVO, to refer to *gross output in the Soviet concept*, which corresponds to the total revenue received by each industrial enterprise *plus* turnover taxes.

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2 Voznesensky, *War economy*, 91.

The gross value of output (GVO) in the Soviet concept double counts inter-enterprise transactions within industry.[3]

On close inspection, the picture reported in Table 1 fails to carry conviction.

First, in neither index is the price set defined. We do not know whether output was calculated at current or constant prices nor, if constant, whether the prices were of `1926/27' or some other base period. Probably `1926/27' prices were used but, as in the case of munitions, this cannot be taken for granted.[4] The Soviet use of constant `1926/27' prices gives no grounds for confidence.

Second, whatever the original definitions, neither index accurately represents the changes in physical outputs and inputs which took place in wartime Soviet industry. Most importantly, the official index of GVO of industry is clearly biased downwards by its understatement of the huge increase in gross output of munitions, which quadrupled between 1940 and 1944.[5]

Third, the two official indices shown in Table 1 (GVO of industry and finished output per manual worker) are not even consistent with each other. Reported output per worker

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3 Rush V. Greenslade, `Industrial production statistics in the USSR', in Vladimir G. Treml and John P. Hardt, eds., *Soviet economic statistics* (Durham, N.C., 1972), 155-94: 171.

4 Mark Harrison, `The volume of Soviet munitions output, 1937-1944: a reevaluation', Warwick Economic Research Paper no. 312 (University of Warwick, 1989), 4-11.

5 Harrison, `Volume of Soviet munitions output', Table 6.

rises by more than it should, given the performance of total output.[6]

There is one previous attempt at an independent estimate of Soviet wartime industrial production, that of Raymond Powell. He took official indices of GVO for nine industrial branches and reweighted them using 1955 employment shares. His index, reported in Table 2, shows Soviet wartime industrial performance in a still worse light than the official index, with 1944 output one fifth lower than the 1940 benchmark, rather than 4 per cent higher in the official version.

Which of these various pictures should we believe? In my view, none of them. Instead, it is necessary to revise the index of industrial production. A revised index results in significantly increased estimates of the change in both total output and output per worker in Soviet industry in war time.

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6 At the time, industrial employment was measured on a strict public sector basis, excluding employment in industrial cooperatives (see further Appendix D). A.V. Mitrofanova, *Rabochii klass SSSR v gody Velikoi Otechestvennoi voiny* (Moscow, 1971), 439, estimates the manual workforce in public sector industry on this basis. When the official index of GVO of industry is adjusted for the change in public sector manual employment, it significantly undershoots the official output per worker index after 1940:

1940 = 100	1941	1942	1943	1944	1945
Gross output per manual worker	110	130	139	142	114
GVO divided by manual workforce	107	116	131	135	106

II

Indices of industrial branch output

I take as my starting point the same official indices of GVO of nine industrial branches which Powell used, also first published in 1965. These are reproduced in Table 3. They are indices of GVO based on the prices of `1926/27'. Seven of them share a common pattern of marked decline, 1940-2, followed by partial recovery. An opposite pattern of wartime expansion followed by cutback in 1945 is shown by the branch closest to munitions output - machine building and metal working (MBMW). An intermediate pattern is displayed by the chemical and rubber industry which had close links with munitions output but which also suffered a serious setback in 1942.

I consider eight of the branch indices to be acceptable for inclusion in a revised index of industrial production as a whole. However, I reject the MBMW index which, as it happens, also accounted for the biggest share of industrial production. In these decisions I am guided by the following arguments.

Machine building and metal working (MBMW). This branch includes the output of the munitions industries, and the official index clearly understates its rise. I have presented elsewhere the reasons for official understatement

of the growth of munitions output in war time.[7] These were no different from the reasons usually resulting in *over*statement of growth of machinery output in time of peace - the rapid change in composition of the product set, the notorious difficulty of pricing new products in terms of the input costs of some far distant base year, and their resulting incorporation into the index at current rather than base-year unit costs and prices.

The understatement of MBMW output growth in the official index can be gauged in the following way. In 1940 munitions output probably represented about three fifths of MBMW output (below, Table 5), and I estimate that munitions output grew at least fourfold over 1940-4. Therefore, the official index number of 158 for 1944 MBMW output implies that civilian MBMW output became negative, which it did not.

Here, the only solution is to estimate the changes in output of civilian and military MBMW separately. I identify military MBMW with munitions output, for which I have estimated a wartime index in earlier work. The index is originally calculated in prices of both 1941 and 1944; here I use the 1941 based variant shown in Table 4.

Civilian MBMW output is more awkward, since there is very little hard information on the volume of civilian output in the war years. There are continuous or nearly continuous series for only three lines of output - metal

7 Harrison, 'Volume of Soviet munitions output', 11-14.

cutting machine tools, tractors and heavy goods vehicles. For other lines production is reported only in 1940 and 1945. I combine these data with various assumptions in order to form a new index, also shown in Table 4. (My sources and methods are reported in Appendix A.)

Iron and steel. How reliable is the official index? We do not know how it was compiled, but we do know the physical units of iron ore, pig iron, crude and rolled steel (including high grade and ordinary rolled steel products separately) which were independently reported in each year, 1940-5. These product groupings were less homogeneous than might appear at first sight.[8] However, there is more basis for measuring output in physical units than in the case of machinery output.

Ideally we would use base year prices or product shares to combine physical units of different products into a new index. However, these value indicators are not available in the form required. As a second best alternative, we can compare the official index with changes in the physical quantities of iron and steel inputs and products in each year. On this basis we can test the hypothesis that the official index is plausibly based on measures of physical

8 Within each product grouping there were wide variations in unit costs of different subproducts. Thus in 1940 the range of official prices of pig iron was 150-356 roubles per ton according to process and quality of output, and of structural steel 283-1,439 roubles per ton according to type of product. See Naum Jasny, *Soviet prices of producers' goods* (Stanford, Ca., 1952), 153.

output which are themselves at least relatively unambiguous and reliable.

The official index of iron and steel GVO is regressed against quantity relatives based on the tons of iron ore, pig iron, crude and rolled steel (including high grade and ordinary rolled steel products separately) produced in each year. In fact, the changes in output of iron ore, pig iron, crude steel and ordinary rolled steel products were all highly collinear, and I select pig iron to represent them on the basis of its t-statistic in a preliminary regression.

When the official index of iron and steel GVO is regressed against indices of pig iron and high grade rolled steel output, while allowing for the presence of a constant term in the regression, a moderately good fit results, the constant being of very weak significance. When the constant is suppressed, the regression and its coefficients become highly significant. The independent variables' coefficients sum to very nearly one, and virtually all the variation in the official index is explained by the variation in the two independent variables. The evidence is consistent with an implicit weight of high grade steel products in 1940 iron and steel GVO of approximately two fifths. Results of regressions are reported in detail in Appendix B.

On this basis I accept the official index of iron and steel GVO for inclusion in a revised index of industrial production.

Fuels. Here I use the same methodology as for iron and steel to test a similar hypothesis - that the official index is plausibly based on measures of physical output which are themselves at least relatively unambiguous and reliable.[9] The official index of fuel GVO is regressed against quantity relatives based on the tons of coal and oil extracted in each year. Again, this is done in two stages, allowing for a constant term and then suppressing it on grounds of weak significance. The results are similar to those for iron and steel. The evidence is consistent with an implicit weight of coal products in 1940 fuel GVO of 62 per cent (for results see Appendix B). Again, I find this sufficient basis to accept the official index of fuel GVO.

Electric power. The official index is found to be plausibly based on a reliable measure of physical output. It is regressed against a quantity relative based on megawatt hours of electricity supplied in each year, with similar results (for details see Appendix B).

Chemicals, rubber. There is no independent test of this index.

Timber. No independent test.

Construction materials. No independent test.

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9 Again, in reality official 1940 coal and oil rouble prices varied widely according to quality and type. See Jasny, *Soviet prices of producers' goods*, 151.

Light industry. The index of light industry GVO cannot be independently tested, but a very weak check is available. The official index can be compared with five official subindices of light industry output which are available for the war years. These cover cotton, woollen and silk weaves, sewn and leather goods. The surplus of `independent' variables compared with observations is overcome by dropping output of silk weaves, which performs worst in regression. The official index is then regressed against the remaining four independent variables. Results (reported in Appendix B) are similar to those previously mentioned. However, the test itself is very weak. The official index cannot be rejected, but only by the standard of other indices of unknown origin and reliability. The more rigorous standard of reported physical outputs cannot be applied.

Food industry. The index of food industry GVO cannot be independently tested against physical product series. The same weaker check as for light industry is theoretically available, but does not produce a useful result. The official index can be compared with four official subindices of food industry output which are available for the war years. However, these cover only meat, fish, dairy products and sugar, and the greater part of food processing - cereal, fruit and vegetable products and alcoholic beverages - is not represented. The results of regression are not significant and are not reported in Appendix B.

Summary. Of the nine original branch GVO indices shown in Table 3, I reject one (that for MBMW) and replace it with the new, independently revised estimates for gross output of military and civilian MBMW separately which are shown in Table 4. I accept the remaining eight, with varying degrees of confidence. Three (iron and steel, fuel and electric power) are checked against relatively reliable measures of physical output and found to be plausible. One (light industry) is similarly checked, although only against other official indices. Four others find no independent support. However, I admit them rather than leave them unrepresented in the new index of industrial production as a whole.

The key decision in all this is to insert a new estimate for military MBMW. By comparison, minor revisions of civilian branch indices have negligible effect on the estimate of industrial production as a whole.

III

Gross outputs, but net weights

The ten (formerly nine) branch indices can now be recombined using appropriate base year weights. I take 1940 as the base year. What kind of weights? Gross outputs can be multiplied by 'gross' weights, or net outputs by 'net' weights, in the sense outlined by Nutter.[10] The meaning of

10 G. Warren Nutter, *Growth of industrial production in the Soviet Union* (Princeton, N.J., 1962), 126.

the alternatives, and the feasibility of choice between them, require some explanation.

Gross output and gross weights require a classification of industrial production by final products. 'Gross output' means finished output, and the appropriate weight of finished output is its price, net only of indirect taxes and subsidies. Intermediate products play no part in this method, because they are subsumed entirely within finished output. Thus the gross output of munitions was the sum of values added in all the stages of extracting, fabricating and assembling the component parts of the weapons of war - not just the final stages of this process which took place in the specialised branches of munitions industry.

On the other hand, net outputs and net weights imply a classification of industrial production by activity in each specialised stage (branch) of fabrication. Final products, intermediate products and materials may all be counted separately. Net output should be weighted by its price, *less* the unit cost of goods and services purchased from other branches. This requires that the output of each branch be understood as the value (net output) added by labour and capital specialised in that stage of fabrication, and that the value added at previous stages be attributed to other branches specialised in those other stages.

Thus the net output of the munitions industries was mainly the specialised work of machining materials and

assembling components which were the intermediate, specialised products of the metallurgical and chemical industries and of civilian MBMW. The electric power used by the munitions industries was the intermediate, specialised product of the power industry, and the fuel used by the power industry was the intermediate, specialised product of the coal and oil industries.

If these rules are followed consistently, then the sum of net outputs of industry by branch should equal the sum of gross outputs of industry by final product, *less* industry's purchases of nonindustrial goods and services.

The procedure which I follow involves multiplying gross outputs by net weights. This is an undesirable compromise, but one to which I can see no alternative. The reason is that the only comprehensive data for Soviet industry in war time are on a specialised branch basis, not on a final product basis; however, output of the specialised industrial branch is measured gross (either gross in the western concept, or GVO in the Soviet concept). Neither final nor net output can be reliably estimated from gross output of the specialised branch. 'Gross' weights cannot be estimated either.

How important is the compromise? Ideally net weights are used to multiply net output. Instead, I measure the change in output of each of the specialised industrial branches using gross output (of military and civilian MBMW)

or GVO (of other branches), not net output. There would already be a small compromise involved in taking the change in branch GVO as a measure of the change in gross output; this makes it necessary to assume no change in the extent of double counted intra-branch transactions over the period.[11] But this is an everyday kind of accommodation. To use the change in gross output as a measure of change in net output creates a more far reaching difficulty.

The difficulty arises because, when branch indices of gross output are summed, the contribution to growth of intermediate goods is double counted. For many purposes this does not matter too much. Even in countries with relatively sophisticated statistical systems, with coherent conceptual tools and open procedures for reporting and analysis, the distinction between changes in gross and net output is regularly blurred.[12] For present purposes, the difficulty is exacerbated by the exceptionally rapid structural change in Soviet industry in war time. Its outstanding feature was the climbing output of finished war goods, coupled with the collapse of all other branch outputs (both finished civilian goods and intermediate goods in general). In particular, in

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11 There was little change in the production branch structure of Soviet industrial administration in war time. Possibly, however, the representative industrial enterprise became more self-sufficient. See Mark Harrison, *Soviet planning in peace and war, 1938-1945* (Cambridge, 1985), 93, 207-8.

12 R.G.D. Allen, *An introduction to national accounts statistics* (London and Basingstoke, 1980), 91-3, details alternative methods used in western statistical systems for indirect estimation of value added in industry .

the munitions branch, finished output most probably grew much faster than the consumption of intermediate goods, and net output grew much faster than gross output.

In a Soviet context, the divergence of net from gross output cannot be guessed without making strong assumptions about changes in output per unit input. Below I present an estimate of the maximum likely increase in gross output per worker and per hour worked in the munitions industries. Implied in this, as a byproduct, is an estimate of the maximum likely divergence of net from gross output of munitions. By 1944 the gross output of munitions, calculated at constant product prices, had reached more than four times the 1940 level. However, the net output of munitions, at constant prices of products and inputs, may have expanded six and a half times over the same period.[13]

A case could be made for replacing my index of gross munitions output (Table 4) by a measure of net output. In the index of total output of Soviet industry in war time, it is more important to get munitions right than any other one thing, because more than any other single branch of activity it is the growth of munitions that dominated industry. The

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13 The index of gross output of munitions (from Table 6) can be compared with the upper bound estimate of net output reported in Appendix E, Table E-4:

1940 = 100	1941	1942	1943	1944
Gross output	159.3	316.5	393.3	435.3
Net output	189.0	437.6	571.7	647.6

weight assigned to munitions in the revised index is a net weight, not the larger gross weight that would represent all the labour, assets and material inputs wrapped up in the final product at every stage. To multiply a more slowly rising gross output index by a relatively restricted net weight must understate the contribution to output growth of munitions activity, and must bias downward the index of industrial production.

Nevertheless, I cannot steel myself to replace gross by net munitions output. There are two reasons why I prefer caution, which means retaining gross output of munitions in the index of industrial production as a whole.

a The reliability of my measure of net munitions output is very low. It is not a firm estimate but, as will be explained later, a maximum likely estimate, which rests on a series of strong assumptions. On the other hand, my measure of gross munitions output is relatively reliable, perhaps even the most sturdy element in the whole index.

b The index of total output is inevitably based on compromise, whatever procedure is followed. The choice is not between compromise and purity, but between a double compromise (net weights multiplying a net output index of munitions, but gross output indices of everything else) and the single compromise which I prefer (net weights multiplying gross outputs of every branch).

This is a problem which I think cannot be reliably solved with the present state of knowledge. Rather than attempt a radical solution, taking all the risks of innovation upon myself, I opt for progress along established lines.

IV

Net output by production branch in 1940

After the character of weights to be used, the most important decision is fixing the 1940 weight of military MBMW. This is a critical choice because the military MBMW index follows a pattern quite different from that shared by the indices for the civilian branches. As a result, small changes in the estimated weight of military MBMW relative to civilian industry will have large effects on the index of industrial production as a whole.

I estimate the 1940 weight of net military MBMW output as 16.1 per cent of net industrial production as a whole, when both are measured in 1937 rouble prices. For this I begin with Bergson's estimates of net output of the munitions and civilian branches in 1937; for the change in their relative magnitude, 1937-40, I use Moorsteen and Powell's index of net output of civilian industries and my own index of munitions output.[14] (For further explanation and alternative estimates, see Appendix C.)

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14 Abram Bergson, *The real national income of Soviet Russia since 1928* (Cambridge, Mass., 1961), 177;

To determine the 1940 weights of civilian branches (including civilian MBMW) I take officially reported 1940 employment of 'industrial production personnel', shown in Table 5. Expressed as percentage shares, they approximate to net output weights on the assumption of uniform net output per worker across the different industrial branches in 1940.

I take the implied share in industrial employment of civilian MBMW as 10.8 per cent, i.e. that for MBMW as a whole (26.9 per cent) *less* the net output share of military MBMW (16.1 per cent).[15]

The employment shares show that the nine original branch indices (in Table 5) covered 93.4 per cent of 1940 industrial employment. I attribute this gap to other civilian employment (mainly nonferrous metallurgy, printing, pottery and glassware), and assume that the output of industrial branches not elsewhere specified grew at the same rate as the output of civilian industry as a whole.

Richard Moorsteen and Raymond P. Powell, *The Soviet capital stock, 1928-1962* (Homewood, Ill., 1966), 622-3; Harrison, 'Volume of Soviet munitions output', Table 6.

15 This makes it possible to combine the indices shown in Table 4 for military and civilian MBMW to generate a new index of output of MBMW as a whole. This can be compared with the official MBMW index (from Table 3) as follows:

1940 = 100	1941	1942	1943	1944	1945
Official	112	119	142	158	129
Revised	119.7	199.0	246.3	275.2	-

These are certainly not the weights used originally by Soviet statisticians to combine the official branch indices into their published measure of gross industrial production. When they are used to weight the branch indices given in Table 3, the result significantly undershoots the official index of total output.

Clearly, gross MBMW output, when measured at `1926/27' prices, is underrepresented by its employment share. The gap between the result of simulated official practice and the published official index can be closed, however, by enlarging the relative share of MBMW. This means assuming that the rouble value of gross output per worker was higher in MBMW than in other branches. By minimising the sum of the squares of the deviations between the two, I impute a differential of rouble value of output per worker in MBMW over other branches as 79 per cent, the official index being closely matched.[16]

However, this is not a reason for correcting the employment share of MBMW for present purposes. It would be

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16 Official indices of branch GVO (Table 3) are weighted by 1940 employment (Table 5), after correcting employment in MBMW for an assumed GVO (in `1926/27' roubles) per worker differential compared with other industry. A correction factor of of 78.7 per cent minimises the sum of squares of deviations of this approximation from the official index, with results as follows:

1940 = 100	1941	1942	1943	1944	1945
The official index	98	77	90	104	92
Best approximation	98.78	78.41	90.93	103.09	90.33

logical to do so only if I were trying to build a new index based on Soviet `1926/27' prices. By 1940 the relative prices of `1926/27' diverged markedly not only from current relative unit costs but also from the relative unit costs which would have been actually incurred had the 1940 nomenclature of industrial commodities been produced in 1926/27. The reason was the tendency to include new products in the list of `1926/27' prices using unit costs current in the period of first production, which were usually much higher than in 1926/27. Evidence from both the interwar and the postwar years suggests that in practice current and `1926/27' prices of Soviet engineering products were nearly indistinguishable.[17] Since the turnover of assortment was more rapid in engineering than in other branches, by 1940 machinery was heavily overrepresented in industrial production measured at `1926/27' prices.[18] As a result, in the 1941 plan, MBMW products accounted for 43 per cent of total industrial production at `1926/27' prices, but only 25 per cent at current production costs.[19]

Therefore I do not try to impute and make use of the weights used at the time in official Soviet statistical practice, and prefer to rely on uncorrected employment

17 Donald R. Hodgman, *Soviet industrial production, 1928-1951* (Cambridge, Mass., 1954), 9-11.

18 Naum Jasny, *The Soviet price system* (Stanford, Ca., 1951), 110-16.

19 Cited by Hodgman, *Soviet industrial production*, 11. This implies an overvaluation of MBMW products relative to other industrial products, when `1926/27' prices are used in place of current production costs, by a factor of 2.24.

shares. This necessitates the strong assumption of uniform value added per worker across the different industrial branches in 1940. There is a precedent for it in the work of Nutter who concluded, after careful investigation: 'In any event, there is no convincing evidence available that an index based on ... employment weights is likely to diverge significantly, in one direction or the other, from one based on ... value-added weights.'[20] It is true that this precedent is probably more reliable for study of industrial growth in peace time, when all the branches of Soviet industry tended to grow at similar rates, than for the years of war which witnessed such violent structural change. However, I see no alternative for it.

The revision process for the wartime index differs from that of Powell (Table 2) in two respects: my use of 1940 rather than 1955 employment weights, and my rejection of the official MBMW index. The second of these is the one which matters. By using employment shares to weight his index, Powell correctly eliminated the role of '1926/27' prices in calculating base year weights, which had been a source of upward bias in the official index after 1940. But he implicitly retained their role in calculating the change in output of each branch after 1940, and this injected a much more powerful tendency to understatement.

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20 Nutter, *Growth of industrial production*, 131.

V

The revised index of industrial production

The revised index of industrial production is reported in Table 6. It matches the official index in 1940-1, then rises substantially above it; it shows that, by 1944, industrial production was not 4 per cent but 20 per cent above the 1940 baseline. This is a natural consequence of the revaluation of munitions output, which is shown to have risen by much more in real terms than the official index allowed.

The revised index is certainly much more reliable than the official one. However, it is less reliable than either of the underlying indices for military MBMW and for civilian industry, shown separately in the table. The reason is that the index for all industry is very sensitive to their relative 1940 valuation. The output of all military goods shared one common pattern, and the output of nearly all civilian goods shared another common pattern, and this increases confidence in the index of each taken separately. But, as Table 6 demonstrates, the two patterns were quite different. When they are combined into a single index, there arises a significant possibility of error.

An unavoidable defect of the new index is its neglect of changing product quality. It measures the volume of output only in the crude sense of numbers of units produced. In the war years the quality of many civilian products fell

below prewar standards, while the quality of military products rose. By how much this might affect the valuation of industrial output seems impossible to say.

VI

Employment and productivity

The next stage is to show industrial production in relation to employment - first for industry as a whole, then on a branch basis. How much did the observed rise of industrial output owe to rising output per worker and per hour worked, and how much to increased employment? To what extent was the change in output per unit of labour input due to the rapidly changing branch composition of output and employment, and how much was due to changes taking place within each industrial branch?

Finding answers turns out to be not at all straightforward. The reason is that the only available series for the industrial workforce after 1940 is incomplete (it is restricted to the public sector and excludes significant employment by industrial cooperatives); this creates a far from theoretical risk that our measures of change in total output and `total' employment will not be comparable with each other.

Moreover, there is virtually no hard information on the branch composition of industrial employment after 1940.

The branch composition of employment matters because it seems highly likely that big gaps emerged between the wartime productivity records of different branches. This is an important issue which demands investigation in itself. According to Voznesensky the unit labour requirements in many branches of munitions work fell by 50, 60 or even 70 per cent in 1941-3. Officially reported finished output per manual worker in MBMW as a whole rose by 31 per cent in 1941-2 and 11 per cent in 1942-3. In contrast, according to reports, 1941-2 was marked by a `temporary decline' in output per manual worker in several civilian branches (the fuel, timber and consumer industries). This setback Voznesensky attributed partly to supply interruptions, partly to the increased role of newly recruited, inexperienced workers.[21]

Divergent productivity performance in different branches is also important because it means that the employment dynamic of industry as a whole cannot be judged from incomplete data, if the missing employees were not scattered randomly across industry but clustered in particular branches. In fact, they were concentrated in civilian work.

Here I outline in brief the procedure which I follow, reserving details of sources and methods for Appendices D (employment) and E (output per worker by branch).

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21 Voznesensky, *War economy*, 91-2.

a Output per worker and per hour worked in the munitions branch are estimated from the change in unit costs of munitions combined with other evidence and assumptions about nonlabour costs.

b Output per worker in munitions work is combined with data on the total output of munitions to generate a series for employment in the munitions branch.

c Employment on munitions work is subtracted from the public sector industrial workforce to yield employment in civilian branches of the public sector.

d Public sector employment on civilian work is grossed up to allow for employment by industrial cooperatives; when employment on munitions work is added back on, we have a new series for the total workforce of public sector and cooperative industry combined (Table 7).

e The revised index of industrial production as a whole, divided by the new total of industrial employees, gives output per worker for all industry. Combined with an estimate of change in hours, it also gives output per hour worked (Table 8).

f Civilian output divided by employment in the civilian branches likewise gives output per worker and per hour worked in civilian industry (Table 9).

This procedure allows us to order the reliability of results, as follows. Most reliable are results for change in labour productivity in industry as a whole. It is true that my estimate for industrial employment can be varied by

adopting different assumptions at preceding stages, but its sensitivity is not high. All that is at stake is the post-1940 dynamic of a minority (19 per cent in 1940) of employees of civilian branches.

Less reliable, because based on undesirably strong assumptions, are the indices of productivity in munitions work. However, I shall show that the Soviet record, reconstructed in this light, is not out of line with other countries' experience of munitions work in World War II.

Least reliable are results for civilian work. Because munitions work was so important in wartime industry, and because productivity in civilian industry is calculated as a residual, small changes in already strong assumptions result in disproportionate variation of results for civilian industry.

The impact of low confidence in results for civilian industry can be mitigated in the following way.

There is an expectation that labour productivity in the Soviet munitions industries in war time rose sharply. The trend of productivity was dominated by the transition to serial production and the realisation of reserve capacities. Of more interest, therefore, is the productivity trend in civilian branches where these favourable circumstances were absent, and where everything else was adverse.

A downward trend of productivity in civilian work would be unsurprising. Favourable movement would be more remarkable. Therefore, wherever there is reasonable doubt over plausibility of alternative assumptions, I choose that alternative which will tend to bias upwards the estimated productivity change in munitions output, and therefore bias downward the resulting estimate of productivity change in civilian industry.

The outcome is not a firm estimate of the most likely course of labour productivity in the two sectors, but an estimate of *the maximum likely range of performance*, taking military MBMW at its best and civilian industry at its worst.

The outcome is also a strong test of the expectation that productivity in civilian branches fell.

VII

Output per worker and per hour worked

Here I present results, not in the order in which they are calculated, but in order of reliability.

Table 8 shows new estimates of the change in output per worker and per hour worked for industry as a whole. Output per worker in industry rose rapidly. By 1944, it was above the prewar level by 70 per cent, not the 42 per cent shown

by the official index of output per worker (Table 1). Output per hour worked also rose steadily until 1944 when it was 39 per cent above the 1940 level, not 16 per cent higher as the official index implied.

Results for industry by branch are shown in Table 9. In the table I report only 'output' and I no longer try to maintain a distinction between gross and net concepts. Output per worker in military MBMW is originally gross output, but is used also as a proxy for net output (subject to warnings listed above). Output per worker in civilian industry is gross output (of civilian MBMW) or GVO (of other branches) used in place of net output and weighted using net (1940 employment) weights.

Table 9 suggests a large increase in output per worker in the munitions industries in war time compared with peacetime standards. I estimate that output per munitions worker may have reached 2.4 times the 1940 level in 1944. Even when the likely increase in hours worked is taken into account, munitions output per unit of labour input in 1944 was still nearly twice the level of 1940.

Are such estimates plausible? The suggested improvement in productivity of Soviet munitions workers, although very large, was not without parallel. It was larger than the increase observed in the United Kingdom, where output per munitions worker probably rose by about one half between the third quarter of 1940 and the first quarter of 1944. But in

Germany, output per munitions worker doubled, and perhaps more than doubled, between 1941 and 1944, *without any increase in hours worked.*[22]

Nonetheless, the increase in output per worker by 1944 in Soviet industry as a whole was so large that it cannot plausibly be accounted for by increased output per worker in the munitions industries alone. Output per worker must have risen in civilian branches of industry as well. However, the increase in civilian industry was probably far less than in munitions production - perhaps one fifth, compared with more than double the output per munitions worker.

Output per hour worked in civilian industry, having sagged in 1940-2, may done no more than recover to the prewar level by 1944. This might seem a disappointing record compared with that of the munitions industries. But given

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22 UK munitions output nearly trebled over this period, while the numbers employed on defence orders nearly doubled; for output see Mark Harrison, 'A volume index of the total munitions output of the United Kingdom, 1939-1944', Warwick Economic Research Paper no. 313 (University of Warwick, 1989), Table 3, and for employment P. Inman, *Labour in the munitions industries* (1957), 5. German munitions output trebled between the end of 1941 and mid-1944 - see *Die deutsche Industrie im Kriege 1939-1945* (Deutsches Institut für Wirtschaftforschung: Berlin, 1954), 191. The German munitions workforce grew by one quarter (from 4.7 to 6.0 millions) over the same period according to Nicholas Kaldor, 'The German war economy', *Review of Economic Studies*, xiii (1946), 33-52: 51, and by 44 per cent (from 2.7 to 3.9 millions) between mid-1941 and mid-1944 according to Burton H. Klein, *Germany's economic preparations for war* (Cambridge, Mass., 1959), 217. Klein's data suggest that finished output per worker in German munitions doubled in three years; Kaldor's suggest still sharper improvement, by 135 per cent in thirty months.

the shambles which the German invasion and Soviet conversion policies had induced in the civilian economy in 1941-2, a recovery of prewar standards of output per unit input in civilian branches of industry while the war continued was probably remarkable in itself.

VIII

Accounting for productivity change

To what extent was the observed rise in output per unit of labour input in industry as a whole due to the rapidly changing branch composition of employment? How much was due to changes taking place within each industrial branch? Now we are one step nearer to an answer.

Assume for the sake of argument that the relative productivity changes estimated in Table 9 took place independently of the fact that munitions work was expanding while civilian work was contracting. Obviously this is unrealistic, because the transition to mass production on a large scale was certainly one of the most important factors underlying growth of munitions output per unit of labour input. It is just a simplifying hypothesis.

Table 10 explores this case. It is apparent that, on these assumptions, all of the productivity gain in industry as a whole in 1940-2 (and more) could potentially be ascribed to the employment shift. In fact, because the

structure of employment was shifting rapidly away from civilian branches with falling productivity to munitions branches with rising productivity, output per hour worked rose on average by 18 per cent in 1940-2. However, if the industrial composition of the workforce had remained unchanged, and if the suggested range of productivity change had still been observed across the branches of industry, then output per hour worked on average would have stagnated or fallen slightly, not risen by nearly one fifth.

After 1942, the pattern of employment stabilised and labour productivity in civilian industry recovered. As a result, productivity gains within each branch of industry became much more important in determining the average level of output per unit of labour input in industry as a whole. This changing role of the branch composition of employment in maintaining output per hour worked is clarified if we take into account the last rows of Table 10, which consider the period 1942-4. All of the productivity gain in this period was attributable solely to improvements within each branch of industry, and none of it represented a composition effect.

However, if we take the whole period from 1940 to the peak of the war effort in 1944, we still find that only two fifths of the 39 per cent improvement in average output per hour worked was attributable solely to improvements within each branch of industry. Workers' movement from civilian to

munitions work may have accounted for the great bulk of the total gain. This is because, without any movement of workers from civilian to munitions work after 1940, assuming an unaltered range of estimated productivity change across the branches of industry, average output per hour worked would have increased by only 15 per cent over 1940 by 1944.

IX

Conclusions

This paper gives rise to four main conclusions.

First, total output and labour productivity in Soviet industry in World War II rose by more than official indices allow. The main reason is official understatement of the expansion of munitions output.

Second, in 1940-2, the main source of growth in output per worker was the increase in hours worked, but after 1942 increased output per hour worked dominated further progress.

Third, it is possible to distinguish between productivity trends in munitions work and in civilian branches. In war time output per hour worked in munitions rose rapidly, while in civilian branches output per hour worked may have sagged before recovering to the prewar level by 1944.

Fourth, in 1940-2 the shift of workers out of civilian work into munitions work may have been decisive in sustaining labour productivity on average but, after 1942, further productivity growth relied for the most part on gains within each sector taken separately.

Table 1. *Gross output, output per worker and output per hour worked in Soviet industry: official measures, 1941-5* (1940 = 100)

	1941	1942	1943	1944	1945
Gross value of output (GVO)[a]	98	77	90	104	92
Gross output per manual worker[b]	110	130	139	142	114
Of which:					
hours worked[c]	-	122	-	-	-
output per hour[c]	-	107	-	-	-

Notes and sources:

a *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-5*, vi (Moscow, 1965), 45.

b *Istoriya*, vi, 74.

c N.A. Voznesensky, *War economy of the USSR in the period of the Patriotic War* (Moscow, 1948), 91.

Table 2. *Powell's estimate of Soviet industrial production, 1941-5*
(1940 = 100)

	1941	1942	1943	1944	1945
Net output, at 1937 prices	93	63	70	78	69

Source: Raymond P. Powell, 'The Soviet capital stock and related series for the war years', in 'Two supplements to Richard Moorsteen and Raymond P. Powell, *The Soviet capital stock, 1928-1962*' (The Economic Growth Center, Yale University, 1968), 7.

Table 3. *Official indices of gross value of output (GVO) by branch of industry, 1941-5*
(1940 = 100)

	1941	1942	1943	1944	1945
Machine building and metal working	112	119	142	158	129
Iron and steel	105	62	70	88	89
Fuels	94	53	59	71	75
Electric power	97	62	67	81	91
Chemicals, rubber	115	79	104	133	92
Timber	88	48	51	55	55
Construction materials	79	26	29	35	41
Light industry	88	48	54	64	62
Food industry	80	42	41	47	51

Source: *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-5*, vi (Moscow, 1965), 59, 63.

Table 4. *Real gross output of Soviet military and civilian MBMW, 1941-5*
(1940 = 100)

	1941	1942	1943	1944	1945
OFFICIAL INDICES (gross value of output):					
MBMW, total[a]	112	119	142	158	129
Of which:					
ground and air munitions[b]	140	186	224	251	-
REVISED INDICES (gross output):					
Military MBMW[c]	159.3	316.5	393.3	435.3	-
Civilian MBMW[d]	61.0	24.9	28.7	38.1	47.1

Notes and sources:

a Table 5.

b *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-5*, vi (Moscow 1965), 45.

c Mark Harrison, 'The volume of Soviet munitions output, 1937-1944: a reevaluation', Warwick Economic Research Paper no. 312 (University of Warwick, 1989), Table 6: total munitions output at 1941 prices, recalculated to show 1940 = 100.

d Appendix A, Table A-3.

Table 5. *Employment of industrial-productive personnel in 1940*

	Thousand[a]	Per cent
MBMW	3 519	26.9
Of which:		
military MBMW	-	16.1[b]
civilian MBMW	-	10.8[c]
Iron and steel	526	4.0
Fuels	808	6.2
Electric power	164	1.3
Chemicals	414	3.2
Timber, paper	1 990	15.2
Construction materials	368	2.8
Light industry	2 853	21.8
Food industry	1 568	12.0
Other industry	869[d]	6.6
All industry	13 079	100.0

Notes and sources:

a *Narodnoe khozyaistvo SSSR v 1965 godu,* (Moscow, 1966), 140.

b The estimated 1940 share of net output of the munitions industries in the net output of industry as a whole, both measured in rouble prices of 1937; see Appendix C.

c Total MBMW *less* military MBMW.

d All industry *less* specified branches.

Table 6. *Revised net output of Soviet industry, 1940-4*

	1940	1941	1942	1943	1944
INDICES (1940 = 100):[a]					
All industry	100.0	97.1	89.2	105.5	120.1
Of which:					
military MBMW	100.0	159.3	316.5	393.3	435.3
civilian industry	100.0	85.3	45.7	50.4	59.8
VALUES (bn 1937 roubles):[b]					
All industry	76.0	73.8	67.7	80.2	91.3
Of which:					
military MBMW	12.2	19.4	38.6	48.0	53.1
civilian industry	63.8	54.4	29.1	32.2	38.1

Notes and sources:

a Official indices of output for branches other than MBMW (Table 3), and revised indices of output for military and civilian MBMW (Table 4), multiplied by adjusted 1940 employment shares (Table 5).

b Revised indices of output of military MBMW, civilian industry and all industry multiplied by the estimated value of 1940 net output (measured in prices of 1937). For the latter, see Appendix C.

Table 7. *Total employment in Soviet industry, 1940-4*
(millions, annual average)

	1940	1941	1942	1943	1944
Public sector	11.0	10.0	7.2	7.5	8.2
Of which:					
military MBMW	2.1	2.5	3.4	3.7	3.8
civilian branches	8.9	7.6	3.8	3.8	4.4
Cooperative sector	2.1	1.8	0.9	0.9	1.0
All civilian industry[a]	11.0	9.4	4.7	4.7	5.4
All industry	13.1	11.8	8.1	8.4	9.2

Source: Appendix D, Table D-2.

Note:

a Civilian branches of the public sector *plus* cooperative sector.

Table 8. *Net output per worker and per hour worked in Soviet industry, 1940-4*

	1940	1941	1942	1943	1944
NET OUTPUT PER WORKER:[a]					
Index	100	107	144	164	170
1937 roubles	5 810	6 240	8 350	9 540	9 880
NET OUTPUT PER HOUR WORKED:[b]					
Index	100	97	118	135	139
1937 roubles	2.95	2.85	3.47	3.96	4.10

Notes and sources:

a Revised net output of industry (Table 6), divided by total employment (Table 7).

b Revised net output per worker, divided by estimated hours worked (Appendix D, Table D-3).

Table 9. *Output per worker and per hour worked in Soviet military MBMW and civilian industry, 1941-4*
(1940 = 100)

	1941	1942	1943	1944
OUTPUT PER WORKER:				
Military MBMW (upper bound)	136	198	223	238
Civilian industry (lower bound)	100	106	118	122
OUTPUT PER HOUR WORKED:				
Military MBMW (upper bound)	123	162	183	195
Civilian industry (lower bound)	90	87	96	100

Sources: See Appendix E, Table E-3.

Table 10. *Growth of average output per hour worked in Soviet industry, 1941-4: the contribution of change in the branch composition of employment*

	1941	1942	1943	1944
Net output per hour worked (1940 = 100):				
actual, revised estimate[a]	96.8	117.8	134.5	139.4
holding constant employment shares of:				
1940	95.2	98.6	110.3	115.0
1942	103.6	117.8	132.3	139.3
Increase in actual output per hour worked over:				
1940, per cent attributable to:				
increased output per worker within each branch	148	-8	30	38
employment shift from civilian to munitions work	-48	108	70	62
total	100	100	100	100
1942, per cent attributable to:				
increased output per worker within each branch	-	-	87	100
employment shift from civilian to munitions work	-	-	13	0
total	-	-	100	100

Notes and sources:

a Table 8.

Appendix A. *Soviet civilian machine building and metal working, 1940-5: a volume index of gross output*

The index proposed below for the war years is based on fifteen physical product series, valued on the basis of machinery prices drawn mainly from the late 1930s or 1940 (I call these the 'approximate rouble prices of 1940'). Reported output is shown in Table A-1, while approximate rouble prices of 1940 are shown in Table A-2.

Of the fifteen series, only one (metal cutting machine tools) is complete and without any missing observations. Two others (heavy goods vehicles and tractors) are complete except for 1941. In all other cases we know output only for 1940 and for 1945; the twelve represented here are selected from a much larger range of physical product data, the sole criterion being the availability of rouble prices.

In the first place I fill in missing 1941 observations for heavy goods vehicles and tractors by interpolation (the method is described in a note to Table A-1). Then, I take the three complete series (machine tools, heavy goods vehicles and tractors) and combine them using approximate rouble prices of 1940, shown in Table A-2. This first subtotal (X), shown in Table A-3, now forms a spine to which remaining missing observations can be joined.

For the twelve other series, I value output in 1940 and 1945, also using approximate rouble prices of 1940. I sum the rouble values to provide the beginning and end years of a second subtotal (Y), also shown in Table A-3. I fill in the missing years 1941-4 of (Y) by interpolation on (X). The method of interpolation is described in a note to the table.

Finally, the two subtotals are summed and calculated as an index based on 1940. These results are reported in Table A-3.

How representative is the new index? As a rough guide we can look at the sum of values estimated for (X + Y) in 1940 - 2.9 billion roubles' worth of finished (gross) output. By comparison, the *net* output of civilian MBMW as a whole in 1940 can be estimated at roughly 8.2 billion roubles of 1937. Therefore, the new index is directly representative of only a small fraction of the full range of civilian machinery products. However, the strong simultaneous variation in its most important elements suggests that it may not be far wrong for the industry as a whole.

Table A-1. *Finished output of Soviet civilian MBMW in physical units, 1940-5*

	1940	1941	1942	1943	1944	1945
Metal cutting machine tools, '000	58.4	44.5	22.9	23.3	34.0	38.4
Heavy goods vehicles, '000[a]	136.0	*81.7*	30.9	45.5	52.6	68.5
Tractors, '000[a]	31.6	*15.4*	3.5	1.1	3.2	7.7
Steam turbines, mW	971.8	-	-	-	-	189.3
Boilers, '000 m²	267.3	-	-	-	-	90.3
Steam locomotives	914	-	-	-	-	8
Pumps, '000:						
centrifugal	21.6	-	-	-	-	16.8
steam	3.5	-	-	-	-	1.3
Electric motors, '000:						
< 100 kW	260.6	-	-	-	-	110.7
> 100 kW	3.1	-	-	-	-	3.2
Generators, '000	4.2	-	-	-	-	2.0
Transformers, '000 mW	3.5	-	-	-	-	1.8
Electric cranes	302	-	-	-	-	194
Diesel engines, '000 hp	255.2	-	-	-	-	18.7
Motor cars	5 511	-	-	-	-	4 995

Source: Output series for machine tools (1940-5), and for heavy goods vehicles and tractors (1940 and 1942-5) are taken from Mark Harrison, *Soviet planning in peace and war, 1938-1945* (Cambridge, 1985), 253. Other series (1940 and 1945 only) are taken from *Promyshlennost' SSSR* (Moscow, 1964), 245-84. Interpolated entries are shown in italics.

Notes:

a Where 1941 output alone is missing, I interpolate the missing figure (Y) on the output of machine tools (X) as follows:

$$Y_{41} = 0.5 \cdot [Y_{40} \cdot (X_{41}/X_{40}) + Y_{42} \cdot (X_{41}/X_{42})]$$

Table A-2. *Approximate rouble prices of products of Soviet civilian MBMW, 1940*

	Unit	Roubles
Metal cutting machine tools	Unit	12 300
Heavy goods vehicles	Unit	8 000
Tractors	Unit	14 000
Steam turbines	1 mW	46 800
Boilers	1 m^2	405
Steam locomotives	Unit	99 500
Pumps:		
centrifugal	Unit	210
steam	Unit	2 900
Electric motors:		
< 100 kW	Unit	436
> 100 kW	Unit	6 283
Generators	Unit	1 931
Transformers	1 mW	22 927
Electric cranes	Unit	35 600
Diesel engines	100 hp	33 111
Motor cars	Unit	9 500

Source: Calculated from rouble price schedules for 1936-7, 1940 and 1944, reported in Naum Jasny, *Soviet prices of producers' goods* (Stanford, Ca., 1952), 166-70.

Table A-3. *Finished output of Soviet civilian MBMW, 1940-5*

	1940	1941	1942	1943	1944	1945
VALUES (mn approximate roubles of 1940):						
X	2 251	1 416	578	666	884	1 128
Y[a]	628	*340*	*139*	*160*	*212*	228
Total	2 879	1 757	717	826	1 096	1 356
INDEX (1940 = 100):						
Total	100.0	61.0	24.9	28.7	38.1	47.1

Source: Physical output of civilian MBMW finished products (Table A-1) valued at approximate rouble prices of 1940 (Table A-2). Interpolated entries are shown in italics.

Notes:

a I interpolate missing entries for (Y) on (X) as follows:

$$Y_t = 0.5 \cdot [Y_{40} \cdot (X_t/X_{40}) + Y_{45} \cdot (X_t/X_{45})]$$

Appendix B. *Measures of the change in output of civilian branches of Soviet industry, 1940-1945*

Table B-1. *Iron and steel*

Year	The official branch index (INDEX)	Pig iron (PIGIRON)	High grade rolled steel (HGRS)
1940	100	100.0000	100.000
1941	105	92.6174	146.875
1942	62	32.2148	106.250
1943	70	37.5839	131.250
1944	88	48.9933	-
1945	89	59.0604	128.125

Dependent variable = INDEX

Explained sum of squares	1355.42	Deg. freedom	2	Mean	677.710
Residual sum of squares	39.3807	Deg. freedom	2	Mean	19.6903
Total sum of squares	1394.80	Deg. freedom	4		

F for regression	34.4184	Probability	0.282339E-01
Multiple correlation	0.985782	Determination	0.971766
Std error of estimate	4.43738	Corrected det.	0.943532

Variable	*Coefficient*	*Standard err.*	*t*	*Probability*
Constant	20.9934	14.7849	1.41992	0.291470
HGRS	0.225782	0.115847	1.94897	0.190629
PIGIRON	0.568445	0.716758E-01	7.93079	0.155295E-01

Dependent variable = INDEX

Explained sum of squares	37610.9	Deg. freedom	2	Mean	18805.5
Residual sum of squares	79.0800	Deg. freedom	3	Mean	26.3600
Total sum of squares	37690.0	Deg. freedom	5		

F for regression	713.409	Probability	0.961082E-04
Multiple correlation	0.998950	Determination	0.997902
Std error of estimate	5.13420	Corrected det.	0.996503

Variable	*Coefficient*	*Standard err.*	*t*	*Probability*
HGRS	0.380545	0.454173E-01	8.37886	0.356519E-02
PIGIRON	0.594212	0.802295E-01	7.40640	0.509164E-02

Table B-2. *Fuel*

Year	The official branch index (INDEX)	Coal (COAL)	Oil (OIL)
1940	100	100.0000	100.0000
1941	94	91.2598	106.1090
1942	53	45.5093	70.7395
1943	59	56.1181	57.8778
1944	71	73.2369	58.5209
1945	75	89.9940	62.3794

Dependent variable = INDEX

Explained sum of squares	1700.77	Deg. freedom	2	Mean	850.384
Residual sum of squares	40.5662	Deg. freedom	3	Mean	13.5221
Total sum of squares	1741.33	Deg. freedom	5		
F for regression	62.8886	Probability	0.355568E-02		
Multiple correlation	0.988283	Determination	0.976704		
Std error of estimate	3.67723	Corrected det.	0.961173		

Variable	*Coefficient*	*Standard err.*	t	*Probability*
Constant	3.61543	6.62685	0.545573	0.623310
OIL	0.342243	0.957661E-01	3.57374	0.374525E-01
COAL	0.601538	0.956098E-01	6.29159	0.811031E-02

Dependent variable = INDEX

Explained sum of squares	35747.4	Deg. freedom	2	Mean	17873.7
Residual sum of squares	44.5910	Deg. freedom	4	Mean	11.1477
Total sum of squares	35792.0	Deg. freedom	6		
F for regression	1603.35	Probability	0.155211E-05		
Multiple correlation	0.999377	Determination	0.998754		
Std error of estimate	3.33882	Corrected det.	0.998131		

Variable	*Coefficient*	*Standard err.*	t	*Probability*
OIL	0.364858	0.783850E-01	4.65469	0.962763E-02
COAL	0.624065	0.782978E-01	7.97041	0.134269E-02

Table B-3. *Electric power*

Year	The official branch index (INDEX)	Electricity supply (ELEC)
1940	100	100.0000
1941	97	96.4803
1942	62	60.2484
1943	67	66.8737
1944	81	81.1594
1945	91	89.6480

Dependent variable = INDEX

Explained sum of squares	1247.37	Deg. freedom	1	Mean	1247.37
Residual sum of squares	2.63398	Deg. freedom	4	Mean	0.658495
Total sum of squares	1250.00	Deg. freedom	5		

F for regression	1894.27	Probability	0.166625E-05
Multiple correlation	0.998946	Determination	0.997893
Std error of estimate	0.811477	Corrected det.	0.997366

Variable	*Coefficient*	*Standard err.*	*t*	*Probability*
Constant	2.09197	1.88825	1.10789	0.330041
ELEC	0.981874	0.225598E-01	43.5232	0.166625E-05

Dependent variable = INDEX

Explained sum of squares	42580.6	Deg. freedom	1	Mean	42580.6
Residual sum of squares	3.44222	Deg. freedom	5	Mean	0.688445
Total sum of squares	42584.0	Deg. freedom	6		

F for regression	61850.4	Probability	0.192891E-10
Multiple correlation	0.999960	Determination	0.999919
Std error of estimate	0.829726	Corrected det.	0.999903

Variable	*Coefficient*	*Standard err.*	*t*	*Probability*
ELEC	1.00648	0.404701E-02	248.697	0.192891E-10

Table B-4. *Light industry*

Year	The official branch index (INDEX)	Cotton weaves (COTTON)	Woollen weaves (WOOL)	Sewn goods (SEWN)	Leather goods (LEATHER)
1940	100	100	100	100	100
1941	88	91	74	94	85
1942	48	36	32	73	47
1943	54	38	35	86	54
1944	64	43	40	10	64
1945	62	41	42	10	60

Dependent variable = INDEX

Explained	sum of squares	2061.33	Deg. freedom	4	Mean 515.332
Residual	sum of squares	0.538552E-02	Deg. freedom	1	Mean 0.538552E-02
Total	sum of squares	2061.33	Deg. freedom	5	

F for regression	95688.5	Probability	0.242455E-02
Multiple correlation	0.999999	Determination	0.999997
Std error of estimate	0.733861E-01	Corrected det.	0.999987

Variable	*Coefficient*	*Standard err.*	*t*	*Probability*
Constant	1.45621	0.269071	5.41200	0.116319
LEATHER	0.131400	0.303306E-01	4.33228	0.144419
COTTON	0.384785	0.101998E-01	37.7247	0.168715E-01
WOOL	0.187966	0.128699E-01	14.6051	0.435210E-01
SEWN	0.281324	0.979193E-02	28.7302	0.221496E-01

Dependent variable = INDEX

Explained	sum of squares	30903.8	Deg. freedom	4	Mean 7725.96
Residual	sum of squares	0.163126	Deg. freedom	2	Mean 0.815630E-01
Total	sum of squares	30904.0	Deg. freedom	6	

F for regression	94723.8	Probability	0.105569E-04
Multiple correlation	0.999997	Determination	0.999995
Std error of estimate	0.285592	Corrected det.	0.999984

Variable	*Coefficient*	*Standard err.*	*t*	*Probability*
LEATHER	0.175522	0.113692	1.54384	0.262614
COTTON	0.380333	0.395648E-01	9.61291	0.106490E-01
WOOL	0.161957	0.464621E-01	3.48578	0.733587E-01
SEWN	0.282201	0.381015E-01	7.40657	0.177453E-01

Sources for Tables B-1 to B-4:

Official branch indices are taken from Table 3 above. In the case of light industry, both the branch index and its component subindices are to be found in *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-5*, vi (Moscow 1965), 63. Other quantity relatives are based on output series measured in physical units, collected by Mark Harrison, *Soviet planning in peace and war, 1938-1945* (Cambridge, 1985), 253.

Appendix C. *The value of Soviet munitions output and of industrial production as a whole in 1940*

Introduction. For the purposes of this paper, and of Tables 5 and 6 above, I accept figures of 12.2 billion 1937 roubles for the net output of the Soviet munitions industries in 1940, and 76.0 billion 1937 roubles for the 1940 net output of Soviet industries as a whole. This gives 16.1 per cent as the percentage share of the munitions industries in industrial production in 1940.

These figures are consistent with most - but not all - estimates previously accepted by Soviet and western authorities. Some of them are listed below. First, however, I mention some conceptual and measurement problems. There are two main sets of complications to watch out for.

Prices. First, different price sets are in use. The most common alternatives are current prices, the supposedly fixed prices of `1926/27' used in Soviet practice, and the fixed prices of 1937 prefered by Bergson, Moorsteen and Powell. Most deceptive is the `1926/27' price set which, by 1940, almost certainly overvalued MBMW products.

Net output. Second, different output concepts are in use. Net output, gross output and gross value of output (GVO) were defined above in the text.

The net output (value added) of the munitions branches was mainly the work of assembling components and materials produced elsewhere. Net munitions output may legitimately be compared with the net output of industry as a whole in order to establish the relative weight of specialised munitions work.

The net weight of munitions output is also comparable with the employment weights for other branches listed above in Table 5, subject only to the limiting assumption of uniform value added per worker in 1940 across the branches of industry.

Gross output. Gross output corresponds to the total revenue received by each branch of the economy, and does not eliminate the cost of purchases from other branches. (For industry as a whole, however, gross output nets out intra-industry transactions). Net of indirect taxes and subsidies, the gross output of each branch should correspond to expenditure on the finished output of the branch.

The gross output of munitions includes the cost of steel, power and chemicals used up in munitions production. It can be compared with the gross output of industry as a

whole in order to show how much of industry's finished output was being absorbed by the armed forces for combat use. But in this case we ought to adjust downward the net weights of civilian branches shown in Table 5 in order not to count twice their role in supplying inputs for the munitions branches.

Gross value of output (GVO). Gross value of output corresponds to the sum of revenues received by each industrial enterprise *plus* turnover taxes, inter-enterprise transactions being double counted. Net of indirect taxes and subsidies, the GVO of each enterprise corresponds to expenditure on its finished output, but the same is not true of the GVO of the branch, or of industry as a whole, because intermediate products are double counted.

GVO and net output. This has well known results - double counting exaggerates the levels of output of industry as a whole, and of the industrial branch, and the degree of double counting can change through time with changing specialisation of the branch and enterprise, causing distortion of the measure of growth. For us, however, it is not so bad. The ratio of the GVO of the munitions branches to the GVO of industry will approximate to the net weight of munitions, assuming a uniform degree of double counting and a uniform ratio of GVO to net output when military and civilian industrial branches are compared.

Is this assumption justified? Probably some distortion is involved. If specialised munitions work involves mainly assembling components and materials produced elsewhere, its ratio of GVO to net output will be above the average for industry as a whole. By how much is impossible to establish. It seems common practice to assume that the ratio was in fact uniform, and a rule of thumb of 2:1 in 1937-40 may not be unjustified.[1] Therefore, figures given below for GVO may be halved as a best guess for the corresponding value of net output.

Alternative estimates:

a Bergson cited the 1937 marketed (≈ gross) output of the defence industry commissariat as 10.0 billion roubles.[2] On this basis he accepted a figure of 5.0 billion roubles for 1937 net output of the munitions branches, together with 60.4 billion roubles as the net output of

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1 For Soviet industry as a whole, the ratio stood at roughly 2.1 in both 1955 and 1959. See G. Warren Nutter, *Growth of industrial production in the Soviet Union* (Princeton, N.J., 1962), 622, 633.

2 Abram Bergson, *The real national income of Soviet Russia since 1928* (Cambridge, Mass., 1961), 377.

civilian industries.[3] Moorsteen and Powell started from these benchmark estimates for 1937 and applied to them, respectively, Bergson's estimate of an increase in real munitions outlays of 2.8 times and their own estimate of the real increase in net output of civilian industrial branches of 5.6 per cent, 1937-40.[4] This would imply 1940 net output of 14.0 billion 1937 roubles for the net output of munitions industries and 63.8 billion 1937 roubles for all industry, with a munitions share of 18 per cent.

b In my present work, I follow Moorsteen and Powell except that I use my own slightly lower estimate of the increase in real munitions outlays of 2.441 times, 1937-40.[5] This gives 1940 net munitions output as 12.2 billion 1937 roubles. When set beside the Moorsteen-Powell figure of 63.8 billion 1937 roubles for the net output of civilian branches, it suggests a 1940 munitions share in value added of 16.1 per cent. Subtracted from the 1940 employment share of MBMW as a whole, given in Table 5 as 26.9 per cent, this leaves the weight of civilian MBMW as 10.8 per cent.

c A Soviet estimate of 1940 national income by end use, at current prices, shows the increase in state reserves in 1940 as 32.0 billion roubles, of which 5.0 billion roubles were used for accumulation.[6] Therefore, 27.0 billion roubles were not used for accumulation, and may be identified with total munitions outlays in that year. This figure of 27.0 billion roubles also corresponds to 7.0 per cent of the figure given for national income produced in 1940, and 7.2 per cent of national income utilised. The share of munitions expenditures in national income in 1940 is given elsewhere by authoritative sources as 7 per cent,[7] which tends to confirm my interpretation of the increase in state reserves not used for accumulation as munitions outlays. (The figure of 27.0 billion roubles is also very close to Bergson's estimate of 1940

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3 Bergson, *Real national income*, 177.

4 Richard Moorsteen and Raymond P. Powell, *The Soviet capital stock, 1928-1962* (Homewood, Ill., 1966), 622-3.

5 Mark Harrison, 'The volume of Soviet munitions output, 1937-1944: a reevaluation', Warwick Economic Research Paper no. 312 (University of Warwick, 1989), Table 6.

6 *Po edinomu planu* (Moscow, 1971), 105-6.

7 N.A. Voznesensky, *War economy of the USSR in the period of the Patriotic War* (Moscow, 1948), 56, gave this as the share of war expenditures other than soldiers' pay and subsistence, but it is clear from *Istoriya Vtoroi Mirovoi voiny 1939-1945*, vi (Moscow, 1976), 340, that expenditures on military equipment only were involved.

munitions outlays at 26.8 billion 1937 roubles.[8]) Since turnover taxes on munitions were negligible, it suggests a 1940 net product of the munitions industries of 13-14 billion current roubles.

d Using the prices of `1926/27', Cooper gives figures of 22.8 billion roubles for 1940 GVO of the defence industry commissariat, 48.4 billion roubles for GVO of MBMW and 137.5 billion roubles for GVO of industry as a whole in the same year.[9] (Nutter gives 139.3 billion roubles for 1940 GVO of industry at `1926/27' prices.[10]) The 1940 GVO share of MBMW in industry was therefore 35.2 per cent, which corresponds closely with a figure of 36 per cent given by Voznesensky for the 1940 MBMW share.[11] The munitions share was 16.6 per cent on this basis. However, the associated share of MBMW looks too high in comparison with its employment share of 26.9 per cent, cited in Table 5. This may be a result of distorted `1926/27' prices. If so, why did the same distortion *not* result in overstatement of the munitions share? The explanation may be that, according to 1941 plan data, munitions were *less* overvalued (in relative terms) by 1926/27 prices than civilian machinery.[12]

e Nutter estimated 31.0 billion roubles as the value of spending on munitions (≈ gross output) in 1940 at current prices. This was on the basis of the stated increase of GVO of munitions in 1939 over 1938, the implied share of munitions outlays in total defence outlays in 1939, and the increase in total defence outlays in 1940 over 1939.[13] He deflated the 31.0 billion current roubles to 24.6 billion roubles of `1926/27', implying 17.7 per cent as the ratio of gross munitions output to GVO of industry as a whole.

f However, from Soviet financial data, Doe has recently estimated the much larger expenditure on munitions in 1941 as only 24.2 billion current roubles.[14]

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8 Bergson, *Real national income*, 366.
9 Julian Cooper, `Defence production and the Soviet economy, 1929-1941', Soviet Industrialisation Project Series no. 3 (University of Birmingham, 1976), 51.
10 G. Warren Nutter, *Growth of industrial production*, 616.
11 Voznesensky, *War economy*, 66.
12 Naum Jasny, *The Soviet price system* (Stanford, Ca., 1951), 100.
13 Nutter, *Growth of industrial production*, 319-22.
14 Frank Doe, `Understanding the Soviet view of military expenditures' (United States Defence Intelligence Agency: Washington, D.C., 1982), Table 4.

g Soviet sources give the 1940 share of industrial output allocated to 'war requirements' (*voennye nuzhdy*) as 26 per cent.[15] There is no indication of the relevant output measure or price set. Anyway, the concept of war requirements is surely broader than munitions alone, and included the claims of the military upon engineering equipment other than munitions, fuel and power, uniforms and processed foods for the army, and so on.

15 *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-5*, vi (Moscow, 1965), 46.

Appendix D. *Employment and labour inputs in Soviet industry, 1940-5*

There is no official series for industrial employment in the war years. There is, however, an authoritative estimate compiled by the Soviet labour historian, A.V. Mitrofanova. Her figures are reported in Table D-1. Their coverage is not very well defined by her, but may be inferred from comparison with official figures for 1940. They are evidently annual averages (based on monthly establishment figures). They are limited to 'industrial-production personnel' (*promyshlenno-proizvodstvennyi personal*), excluding those providing training or other services to the workforce . They show total employment of manual and white collar workers (*rabochie i sluzhashchie*), inclusive of engineering and technical personnel (*ITR*), apprentices, 'junior service personnel' (*mladshii obsluzhivayushchii personal*) and security staff (*rabotniki okhrany*). There is also a subtotal for manual workers alone (*rabochie*), but this is not a fully independent series because in two crucial years (1942 and 1943) it is interpolated on total employment.

The main defect of Mitrofanova's estimates is that they are limited to the public sector on a narrow definition, and exclude employment in industrial producers' cooperatives (*artely promkooperatsii*). This was the normal practice followed in reporting industrial employment in Soviet statistical handbooks until the 1960s. In 1960, the industrial cooperatives were absorbed into the public sector, and thereafter industrial employment reported for previous years was corrected to include these establishments.[1] There are thus two 'official' figures for 1940 'industrial-production personnel', the earlier figure of 10,967,000 (the basis for Mitrofanova's 11.0 millions) and a later figure of 13,079,000 which includes industrial cooperatives. It can be seen that employment in industrial cooperatives was therefore quite significant - more than 2 millions in 1940 (the figure fell to 1.6 millions in 1955 and one million upon absorption into the public sector in 1960).

Unfortunately, there is no official series to extend the later, more inclusive figure into the war period.

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1 The correction was introduced in 1966. Compare *Narodnoe khozyaistvo SSSR v 1964 godu* (Moscow, 1965), 135-6 and *Narodnoe khozyaistvo SSSR v 1965 godu* (Moscow, 1966), 140. See further Murray Feshbach, 'Soviet industrial labour and productivity statistics', in Vladimir G. Treml and John P. Hardt, eds., *Soviet economic statistics* (Durham, N.C., 1972), 195-228: 204-7.

Which employment concept is most relevant to us - with or without the industrial cooperatives? In my view they should clearly be included. The reason for this is that the measures of industrial production developed in this paper clearly included industrial cooperatives' output. Therefore, our measures of employment and labour inputs should incorporate the industrial cooperatives too.

It would be possible simply to take Mitrofanova's estimate of total employment in each year and multiply it by a constant correction factor of 1.19, being the ratio of the two aggregates (with and without the industrial cooperatives) in 1940. But this would almost certainly overstate industrial employment in the years after 1940. A constant correction factor would imply that employment in industrial cooperatives behaved in the same way as industrial employment as a whole. In reality, it probably fell by much more, being concentrated (more than 90 per cent in 1960) in branches other than MBMW.[2] There was little evacuation of cooperative establishments' capacity from the territories occupied in 1941-2. It is true, on the other hand, that the war years saw significant conversion of cooperative establishments' capacity to the needs of war production.[3] But in these respect the forces acting upon industrial cooperative employment were no different from those acting upon employment in civilian work generally. The appropriate assumption, therefore, is that cooperative employment followed the same dynamic as employment in the *civilian branches* of public sector industry.

The interpolation of employment in industrial cooperatives is shown in Table D-2. First, employment in military MBMW is estimated (below, Table E-3) from gross munitions output and output per worker employed. The figures for change in output per worker employed on munitions work are an upper-bound estimate, so this gives a lower bound for change in employment in military MBMW). Second, employment in military MBMW is subtracted from employment in public sector industry to leave employment in the civilian branches of the public sector as a residual (in this case, an upper bound for years after 1940). Third, employment in industrial cooperatives is interpolated on this residual. Last, it is added to public sector employment to give an estimate (an upper bound after 1940) of the total industrial workforce.

It remains to convert employment into labour inputs (hours worked). In Table D-3 I report the official figure for days actually worked per manual worker in industry in 1940 (263 out of 303.7 days maximally available). The number

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2 Feshbach, 'Soviet industrial labour', 207.

3 E.V. Zarutskaya, 'Mestnaya promyshlennost' i promkooperatsiya RSFSR', in *Sovetskii tyl v Velikoi Otechestvennoi voiny*, ii (Moscow, 1974), 293-4.

of hours worked per day changed in mid-year, under the legislation of June 1940, from seven to eight. This suggests a figure of nearly 2,000 hours worked per worker during the year. According to Voznesensky, the hours worked on average by manual workers in industry in 1942 exceeded those of 1940 by 22 per cent. I assume that the transition to increased hours took place abruptly in mid-1941, and that the higher hours of 1942 were maintained through 1943-4. Thus the steep decline in number of workers employed was made good to a limited extent by increased utilisation of workers' former leisure time.

Table D-1. *Mitrofanova's estimate of employment in public sector industry, 1940 and 1942-5*
(millions, annual average)

	1940	1942	1943	1944	1945
Total[a]	11.0	7.2	7.5	8.2	9.5
Of which: manual	8.3	5.5[b]	5.7[b]	6.4	7.2

Source: A.V. Mitrofanova, *Rabochii klass SSSR v gody Velikoi Otechestvennoi voiny* (Moscow, 1971), 439.

Notes:

a Industrial-production personnel, excluding members of industrial cooperatives.

b Estimated on the 1940 proportion of 76 per cent of total industrial-production personnel.

Table D-2. *Estimated total employment in Soviet industry, 1940-4*
(thousands, annual average)

	1940	1941	1942	1943	1944
Public sector[a]	10 967	10 025	7 200	7 500	8 200
Of which:					
military MBMW[b]	2 100	2 452	3 365	3 698	3 838
civilian branches[c]	8 867	7 573	3 835	3 802	4 362
Cooperative sector[d]	2 112	1 804	913	906	1 039
All industry[e]	13 079	11 829	8 113	8 406	9 239

Notes:

a For 1940, *Narodnoe khozyaistvo SSSR* (Moscow, 1956), 190. For 1941, I assume that employment averaged the 1940 level in the first three quarters of the year, and the 1942 level in the last quarter. For 1942-4, Table D-1.

b Table E-3.

c Public sector employment *less* employment in military MBMW.

d For 1940, employment in all industry *less* employment in the public sector. For 1941-4, 1940 cooperative employment multiplied by the change in employment in civilian branches of the public sector.

e For 1940, *Narodnoe khozyaistvo SSSR v 1965 godu* (Moscow, 1966), 140. For 1941-4, public sector employment *plus* cooperative employment.

Table D-3. *Estimated hours worked by manual workers in Soviet industry, 1940-4*

	1940	1941	1942	1943	1944
PER WORKER:					
Days worked per year[a]	263	-	-	-	-
Hours worked:					
per day[b]	7.5	-	-	-	-
per year[c]	1 973	2 189	2 406	2 406	2 406
TOTAL:					
Current years worked[d]	13 079	11 829	8 113	8 406	9 239
1940 years worked[e]	13 079	13 130	9 898	10 255	11 272

Notes:

a *Promyshlennost' SSSR* (Moscow, 1964), 87.

b The normal working day for workers in most branches of the economy was raised from seven to eight hours in mid-1940. See *Izvestiya*, 27 June, 1940.

c For 1940, days worked per year *times* hour worked per day. For 1941, I assume an average of 1940 and 1942. For 1942 I apply the 22 per cent increase over 1940 reported by N.A. Voznesensky, *War economy of the USSR in the period of the Patriotic War* (Moscow, 1948), 91 (see Table 1, above). For 1943-4 I assume no change over 1942.

d Table D-2.

e Current years worked *times* the change in hours worked per year over 1940.

Appendix E. *Output per worker and per hour worked in Soviet military MBMW and civilian industry, 1940-4*

Introduction. For military MBMW, I begin by defining a set of variables the change in which is known or can be estimated:

Q_t	quantity produced (gross output), units
L_t	labour input (hours worked)
q_t	real output per worker (Q_t/L_t)
p_t	price per unit of output
w_t	wage earnings per hour worked
n_t	price per unit of nonlabour input

In order to determine the role of nonlabour inputs, I set the following as a constant:

m	nonlabour input, quantity per hour worked

Here I include all nonlabour costs of production for the industry - overheads, materials and power, and purchases from other sectors. To support the definition of (m) as a constant I assume:

Equal change in labour and nonlabour input productivity [1]

That is, any change in output per unit of nonlabour input was proportional to the change in output per unit of labour input, so that if the output of munitions per hour worked rose by a given percentage, then output per ton of steel or per unit of electric power used also rose in the same proportion, while fixed costs per unit of output fell similarly. This is not far fetched according to contemporary accounts.[1] If it was so, then the quantity of nonlabour inputs used per hour worked remained constant.

To get the ball rolling, a second assumption is now required, as follows:

Average cost pricing in military MBMW [2]

In symbols,

$$p_t \cdot Q_t = (w_t + m \cdot n_t) \cdot L_t \qquad [2a]$$

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1 B.P. Orlov, 'Sovetskaya promyshlennost' v period Velikoi Otechestvennoi voiny', *EKO*, no. 5 (1985), 3-18: 15-16.

that is, industry revenue covered industry total costs (gross output).[2] From it there follows:

$$q_t = (w_t + m \cdot n_t)/p_t, \quad \text{where } q_t = Q_t/L_t$$

Therefore,

$$q_t/q_o = p_o/p_t \cdot (w_t + m \cdot n_t)/(w_o + m \cdot n_o)$$

which, rearranged, tells us that:

The change in gross output per hour worked can be inferred from the fall in unit prices, the increase in costs of labour and nonlabour inputs, and the ratio of nonlabour costs to labour costs in the initial period. [3]

In symbols:

$$q_t/q_o =$$

$$p_o/p_t \cdot (w_t/w_o + [m \cdot n_o/w_o] \cdot [n_t/n_o])/(1 + m \cdot n_o/w_o) \quad [3a]$$

The right hand side of equation [3a] can be quantified by estimation or assumption as follows.

Unit prices. Current weighted indices of procurement prices can be derived separately from official information for

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2 This assumption would have caused Jasny a lot of trouble. He expressed outright disbelief about the claimed reductions in unit labour requirements in munitions work, and argued that the fall in procurement costs required a matching increase in subsidies. See Naum Jasny, *The Soviet price system* (Stanford, Ca., 1951), 107. To me, the claimed reductions do not seem out of the question. The increase in labour productivity estimated on this basis is not out of line with international experience of munitions work in World War II (reviewed in the text, above), nor does it cause any troublesome anomalies below when its impact on aggregate labour requirements is reviewed. The scale of wartime budget subsidies to industry as a whole, which rose to 6.5 billion roubles in 1944, was small in relation to munitions output of perhaps 76 billion current roubles.

In Table E-1 1944 munitions prices are shown as 60 per cent of 1940, but in 1940 according to Abram Bergson, *The real national income of Soviet Russia since 1928* (Cambridge, Mass., 1961), 367, munitions prices were probably 20 per cent above 1937. In Table E-4, gross output of munitions in 1944 is shown as 106.2 billion 1937 roubles. For reported budget subsidies see A.G. Zverev, *Voprosy natsional'nogo dokhoda i finansov SSSR* (Moscow, 1958), 212-13.

ground and air munitions, 1940-5, and naval munitions, 1941-4, and are given below in Table E-1. The two indices are combined into a single index using 1944 expenditure weights of 92.7 per cent and 7.3 per cent respectively.[3] I assume that in 1940-1 the procurement costs of naval munitions fell in the same proportion as for ground and air munitions. I take the result as my measure of (p_t/p_o) in Table E-2. The percentage decline in unit prices of 40 per cent shown in the table for the period 1940-3 coincides closely with the 42.6 per cent fall in unit costs which can be calculated from official statements for the whole engineering industry year by year in the same period.[4]

Hourly earnings. According to official sources, average monthly earnings of manual workers in all-Union industries rose from 375 roubles in 1940 to 573 roubles in 1944.[5] Of course, the money earnings of munitions workers did not necessarily change in the same proportion as earnings in industry as a whole. According to Mitrofanova there was some increase in earnings inequality during the war, and the spread widened in favour of workers in heavy industry. However, the data which she cites do not show this; earnings of workers in the armament and ammunition industries rose by 50 per cent over 1940-5, but this was no more than the average increase for all industrial workers, 1940-4.[6] Munitions workers' earnings in 1945 were probably affected adversely by difficulties resulting from the onset of peacetime reconversion, but there is nothing to indicate their earnings in 1944. Therefore, I have no real difficulty in sticking to the change in officially reported monthly earnings for industrial workers as a whole.

I assume that hours worked by munitions workers in 1942 were 22 per cent in excess of hours worked in 1940, as they were for industrial workers generally (Table D-3), and I assume that they remained unchanged over 1942-4. In that case, hourly earnings had risen by 25.2 per cent. I assume that this growth was achieved in equal proportional increases of 5.8 per cent annually. Of course, this means that the biggest inflation of monthly earnings was concentrated in 1940-2 when hours worked rose sharply. This gives a measure of (w_t/w_o) in each year for Table E-2.

Nonlabour input costs. For (n_t/n_o) I take an index of wholesale prices of material inputs into munitions, compiled

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3 Mark Harrison, 'The volume of Soviet munitions output, 1937-1944: a reevaluation', Warwick Economic Research Paper no. 312 (University of Warwick, 1989), Table 5.

4 N.A. Voznesensky, *War economy of the USSR in the period of the Patriotic War* (Moscow, 1948), 108.

5 Voznesensky, *War economy*, 94.

6 A.V. Mitrofanova, *Rabochii klass SSSR v gody Velikoi Otechestvennoi voiny* (Moscow, 1971), 497-9.

by Bergson from price indices for high grade steel, nonferrous rolled metal products and inorganic chemicals, for 1940 and 1944 (1937 = 100).[7] This index has to carry a lot of weight, because it is taken to represent the changing cost of nonmaterial inputs into munitions as well - financial and transport services, for example. I recalculate the index to show 1940 as the base year, and assume equal proportional increases in each missing year, 1941-3.

The ratio of nonlabour costs to labour costs. Nutter estimated the production account for gross and net output of Soviet industry as a whole for 1955 and 1959.[8] From each account I take the ratio of the sum of profits (including subsidised losses) *plus* commercial outlays (including miscellaneous charges) *plus* cost of materials consumed (including amortisation) to employee compensation. This ratio stood at approximately 4.2 in 1955 and 5.1 in 1959.

For purposes of Table E-2 I select a value for $(m \cdot no/wo)$ of 4.0. This arises from the following considerations. On one hand, it could be argued that this ratio was probably higher in MBMW than in other branches less distant from primary production. This would push us towards the higher end of the range. On the other hand are two countervailing arguments. First, there was arguably an upward trend in the ratio over the periods 1940-55 and 1940-59, arising from the extensive industrial growth pattern. This pushes us towards a lower figure. Second, a lower figure tends to push up our estimate of productivity growth in munitions production, and gives us a more conservative estimate of productivity growth in civilian industry. In any case, estimated (q_t/q_o) is very insensitive to the hypothesised value of $(m \cdot no/wo)$, and varying the latter even between 6.0 and 2.0 will make very little difference.

Productivity in munitions. When these values of (p_t/p_o), (w_t/w_o), (m_t/m_o) and $(m \cdot no/wo)$ are inserted into equation [3a], the result is the index of (q_t/q_o), output per hour worked in military MBMW, 1940 and 1942-4, which is shown in Table E-2.

We can get from this to civilian output per hour worked as follows.

Munitions employment. Table E-3 shows total net output of military MBMW and civilian industries, 1940-4, expressed in billion roubles of 1937. Consistently with our assumption of uniform net value added per worker in the different industrial branches in 1940, we can divide the 13.1 million industrial employees reported for that year (Table D-2

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7 Bergson, *Real national income,* 367.

8 G. Warren Nutter, *Growth of industrial production in the Soviet Union* (Princeton, N.J., 1962), 622, 633.

above) in the same proportions, and this gives us an estimated 2.1 million munitions workers in 1940.

To derive munitions employment in subsequent years, we need a series for output per worker. We already have the estimated change in output per hour worked (from Table E-2). In Table 8 above this is already converted into an estimate of the change in output per worker, consistently with our evidence and assumptions about hours worked in industry as a whole (Table D-3). The change in total munitions output, divided by the change in output per worker, yields the change in employment in 1942-4 over 1940. This, multiplied by initial employment, gives total employment in the munitions industries in each year (Table E-3).

Civilian employment and productivity. Employment in civilian branches of public sector industry is now obtained as a residual, and grossed up to include the cooperative sector (this was shown in Table D-2). Divided into the net output of civilian industries, it yields series for output per worker and (on the basis of the same assumptions applied to military MBMW) per hour worked Table E-3).

Gross and net output of munitions. Table E-4 shows, as a byproduct, the estimate of real net output of the munitions branches which is implicit in this procedure. The index of finished output of munitions is given a value in 1937 roubles consonant with the assumption that 1940 net output was half gross output (Appendix C). For the years after 1940 I assume that the volume of intermediate goods and services utilised in military MBMW moved in fixed proportion to labour inputs in that branch. Net output of military MBMW is then found as a residual (finished output *less* interbranch inputs).

Table E-1. *Unit procurement prices of Soviet munitions, 1941-5*
(1940 = 100)

	1941	1942	1943	1944	1945
Ground and air munitions	84.5[a]	65.8	60.4	59.0	56.8
Naval munitions	84.5[b]	77.7	71.5	67.9	-
All munitions	84.5	66.6	61.2	59.7	-

Source: Calculated from *Finansovaya sluzhba Vooruzhennykh Sil SSSR v period voiny* (Moscow, 1967), 63, 66, 80, 84, 86, 87, 354. See Mark Harrison, 'The volume of Soviet munitions output, 1937-1944: a reevaluation', Warwick Economic Research Paper no. 312 (University of Warwick, 1989), 13, for further information on sources and methods.

Note:

a Harrison, 'Volume of Soviet munitions output', assumed that ground and air munitions prices were stable in 1940-1. The present series differs by including an estimate of the price reduction at that time. This is based on comparing the saving from price reductions which would have accrued to the budgetary authorities in 1941, had munitions expenditure been realised according to plan, with actual munitions expenditure.

b Assumed to be the same as for ground and air munitions.

Table E-2. *Derivation of output per hour worked in Soviet munitions industries, 1941-4*
(1940 = 100)

	1941	1942	1943	1944
p_t/p_o	84.5	66.6	61.2	59.7
w_t/w_o	105.8	111.9	118.4	125.2
$m \cdot n_o/w_o$	4	4	4	4
n_t/n_o	103.4	106.9	110.5	114.3
q_t/q_o	122.9	161.9	183.1	195.3

Source: See text of appendix and, for (q_t/q_o), equation [3a].

Table E-3. *Derivation of output per worker and per hour worked in military MBMW and civilian industry, 1940 and 1942-4*

	1940	1941	1942	1943	1944
NET OUTPUT (billion 1937 roubles):					
All industries[a]	76.0	73.8	67.7	80.2	91.3
Of which:					
military MBMW[a]	12.2	19.4	38.6	48.0	53.1
civilian industry[a]	63.8	54.4	29.1	32.2	38.1
EMPLOYMENT (millions):					
All industries[b]	13 079	11 829	8 113	8 406	9 239
Of which:					
military MBMW[c]	2 100	2 452	3 365	3 698	3 838
civilian industry[b]	10 979	9 377	4 748	4 707	5 401
OUTPUT PER WORKER (1937 roubles):					
All industries[d]	5 810	6 240	8 350	9 536	9 878
Of which:					
military MBMW[e]	5 810	7 928	11 479	12 977	13 839
civilian industry[d]	5 810	5 799	6 132	6 832	7 063
OUTPUT PER HOUR WORKED (1937 roubles):					
All industries[f]	2.95	2.85	3.47	3.96	4.10
Of which:					
military MBMW[g]	2.95	3.62	4.77	5.39	5.75
civilian industry[f]	2.95	2.65	2.55	2.84	2.94

Notes and sources:

a Table 6.

b Table D-2.

c For 1940, 16.1 per cent (from Appendix C) of total employment (13,079,000, from Table D-2). For other years, 1940 employment multiplied by the change in output (above), divided by the change in output per worker (below).

d Net output divided by employment.

e For 1940, output per worker in industry as a whole. For other years, 1940 output per worker, multiplied by the

change in output per hour worked (below), divided by the change in hours worked (Table D-3).

f Output per worker divided by hours worked (Table D-3).

g For 1940, output per hour worked in industry as a whole. For other years, 1940 output per hour worked multiplied by (q_t/q_0) (Table E-2).

Table E-4. *From gross to net output of military MBMW, 1941-4*

	1940	1941	1942	1943	1944
Gross output of military MBMW, bn 1937 roubles[a]	24.4	28.9	77.3	96.0	106.2
Hours worked in military MBMW, 1940 = 100[b]	100.0	129.6	195.4	214.8	222.9
Interbranch inputs transferred to military MBMW, bn 1937 roubles[c]	12.2	15.8	23.9	26.2	27.2
Net output of military MBMW, (upper bound):[d]					
bn 1937 roubles	12.2	23.1	53.4	69.8	79.0
1940 = 100	100.0	189.0	437.6	571.7	647.6

Notes and sources:

a From Appendix C, 1940 gross output is taken as 24.4 billion roubles, twice the figure for net output which is accepted there and above. For 1941-4, see Table 4.

b This is an index of employment in military MBMW (from Table D-2, multiplied by an index of average hours worked (from Table D-3).

c Interbranch inputs in 1940 are assumed equal to half of gross output (Appendix C). For 1941-4 I assume that interbranch inputs move in proportion to labour inputs. This is based on proposition [1] above (`Equal change in labour and nonlabour input productivity´), which implied that the quantity of nonlabour inputs used per hour worked remained constant.

d Gross output *less* interbranch inputs.