THE VOLUME OF SOVIET MUNITIONS OUTPUT, 1937-1944: A REEVALUATION

by

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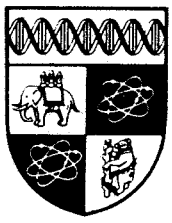

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Abstract

The paper examines the official Soviet index of munitions output in World War II which was first published in 1965. This index seems to have been based on annual budgetary appropriations for expenditure on ground and air munitions at current prices; since Soviet munitions prices fell rapidly in war time, it grossly understates change in the real volume of war production. Subsequently published official data on the production of different lines of ground and air munitions in physical units, supplemented by information about real spending on naval munitions, supply a reliable foundation for a new index of the volume of total munitions output. New indices for different branches of the munitions industries can be calculated in Soviet prices of either 1941 or 1944, and combined using weights based on 1941 and 1944 expenditure shares. The result shows that Soviet munitions output underwent a fourfold expansion between 1940 and the 1944 peak. The new index can also be extended back to 1937, although with some loss of reliability. When this is done, Soviet munitions output at the 1944 peak is shown to have run at 10-11 times the 1937 rate. Lastly, the level and dynamic of Soviet munitions output measured in this way can be compared with the performance of similar measures of munitions output in World War II in other countries.

Acknowledgements

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The volume of Soviet munitions output, 1937-1944: A reevaluation

Mark Harrison

I

Introduction

The only available summary measure of the total Soviet output of munitions in World War II is an index which was first published in 1965, in the sixth, final volume of the *Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941-1945* ('History of the Great Patriotic war of the Soviet Union, 1941-1945', hereafter *IVOVSS*). Below I shall call it the *Istoriya* index. It covered the years 1940-4; it was said to be based on the output of the four main commissariats supplying the ground and air forces, which covered the aircraft, tankbuilding, armament and ammunition industries respectively. Also published with it were subindices showing the output of each of the four commissariats separately for the years 1940-5. The *Istoriya* index and its four subindices are reproduced in Table 1.

The *Istoriya* index was probably first compiled during or immediately after the war. It showed that the output of Soviet ground and air munitions at the 1944 peak stood at 251 (in comparison with 1940 = 100). This formed the basis for Voznesensky's statement in 1947 that 'war production in

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Table 1. *The* Istoriya *index of Soviet munitions output, 1940–5*

Year	The *Istoriya* index	By industrial commissariat:			
		Aircraft	Tank-building	Armament	Ammunition
1940	100	100	100	100	100
1941	140	126	112	145	152
1942	186	178	184	191	218
1943	224	223	234	200	264
1944	251	239	296	206	310
1945	–	177	276	156	171

Source: *IVOVSS*, vi (1965), 45, 52.

the eastern and central areas of the U.S.S.R. alone increased during the Patriotic War two and a half times over in comparison with the 1940 production level for the whole of the U.S.S.R.'[1] After Voznesensky's book about the war economy there was a blackout on the publication of further statistical information from the war period, and this explains the long delay in full publication of the *Istoriya* index.

The *Istoriya* index continues to be republished in official statistical handbooks and to be cited as authoritative up to the present day. (In subsequent publications the *Istoriya* index has often been represented as an index of total munitions output rather than of the main types of ground and air munitions.) Soviet writers have never questioned its reliability as a guide to Soviet munitions output in war time.

The problem is that it is far from clear what these index numbers were really meant to measure. Whatever else, it is certain that they *do not* satisfactorily measure quantities of weapons produced. Detailed time series for different lines of war products, denominated in physical units, have been published subsequently in the official twelve-volume *Istoriya Vtoroi Mirovoi voiny 1939-1945* ('History of the Second World War, 1939-1945', hereafter

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1 Voznesensky (1948), 63.

IVMV).[2] These make it absolutely clear that the *Istoriya* index numbers greatly understate the growth of munitions production from the beginning of the war to the wartime peak in 1944.

For example, four times as many military aircraft were produced in 1944 as in 1940, compared with the peak output of 2.4 times the 1940 level recorded by the *Istoriya* index for the aircraft industry. A larger discrepancy is found in the case of armoured fighting vehicles; more than ten times as many units were produced in 1944 as in 1940, while the industry's *Istoriya* index grew to only three times. The armament industry's *Istoriya* index for 1944 stands at only twice the 1940 level. However, the number of heavy guns produced in 1944 was more than six times the 1939 level, that of light guns nearly eight times (and in 1939 *more* guns were manufactured than in 1940); the 1944 output of machine pistols was 24 times the 1940 level, that of machine guns three times, and only the increase in supply of rifles and carbines falls below the index. As for ammunition, the official *Istoriya* index shows 1944 output as three times the 1940 level, but this is somewhat less than the increase in the supply of shells and mines recorded for 1944 over 1941; the output of shells taken separately had expanded to more than nine times 1940 output already by 1943.

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2 See relevant sections of *IVMV*, i-xii (1973-82). Detailed series of physical output are brought together from this and other sources in Harrison (1985), 250-2.

Discrepancies on this scale and pattern cannot possibly be explained by changes in either the composition or the quality of Soviet munitions produced in war time. Only in the aircraft industry was there any shift away from bigger, more complex and expensive types of output to cheaper types, and the scale of the shift was too slight to account for more than a small part of the gap between change in numbers produced and change in the industry's subindex. Overall, the quality of Soviet munitions rose in war time, and should have further boosted the valuation of real munitions output above any measure based on crude numbers of products.

The physical product series provide the basis for a revised index of the volume of total Soviet munitions output, which is presented below. First, however, I try to explain the character of the existing *Istoriya* index of total output and the four industry subindices.

II

The Istoriya *index*

There are two problems with the *Istoriya* index: prices and coverage. First, what was the price set used to compile it? The context of its first publication made it look like a volume index calculated at fixed prices, although nothing was said in writing. It was entered in a table as a subindex of gross industrial production (normally measured for this

period at the so-called fixed prices of 1926/27), alongside various other indicators of wartime economic activity, for the most part denominated in fixed prices (e.g. national income, measured at '1926/27' prices) or in physical terms (e.g. millions of people in employment). Yet we have seen that the expansion of the *Istoriya* index lags too far behind the reported growth in physical output of war products for it to be understood as a measure of volumes.[3]

Second, what was the *Istoriya* index intended to cover? It was originally published in the form of a weighted sum of the four subindices for the industries supplying aircraft, tanks, guns and ammunition. However, this too may have been misleading.

The immediate problem is that, if the *Istoriya* index is really the weighted average of the four subindices, then there must be a mistake in the reported totals. For simple algebra shows that the behaviour of the *Istoriya* index as reported cannot in fact be explained by the variation in the four subindices. One possible way out of the inconsistency

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3 Previously I considered various possible explanations - that the *Istoriya* index was based on changes in values, not volumes, or that its behaviour was seriously affected by changing boundaries in the administration of war production. See Harrison (1985), 119-21. At one time, also, I thought the munitions index must be calculated at '1926/27' prices, and that its peculiarities would be attributable to the largely fictive character of this price set. If deflation of values by Soviet 'fixed' prices results in overstatement of real output growth when unit costs are rising and quality is falling, then the opposite case surely held for munitions output in wartime.

would be to assume an error somewhere, whether deliberate or typographic. The likeliest candidate for a mistake is the 1941 entry of the *Istoriya* index, which is too high.[4] This hypothesis is attractively simple, but I reject it in favour of an alternative.

My preferred hypothesis is as follows. The *Istoriya* index is inconsistent with the four industry subindices primarily because it is an index of expenditure, not production. The coverage of production is inconsistent with that of expenditure. The *Istoriya* index is more comprehensive than would appear from the source, and includes spending on branches of munitions additional to those counted under the four subindices.

Identifying the *Istoriya* index as a measure of expenditure, not production, also helps to solve the pricing problem. It is an index of total expenditure on ground and

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4 The entries of the total index for 1940-3 can be taken as the right hand sides of four simultaneous equations, with the four 1940 weights of the subindices as unknowns. In this case, there is no set of nonnegative solutions which can satisfy the constraints. Moreover, the entry for total munitions output in 1944 of 251 cannot be matched by combining the subindices using weights imputed in this way. When the entries of the total index for 1940 and 1942-4 are taken as the right hand sides of the four simultaneous equations, again with the four 1940 weights of the subindices as unknowns, feasible and realistic weights result, but now the entry for total munitions output in 1941 is estimated at 130, not the 140 given. This might be consistent with a typographic or arithmetic error in the official index for 1941. The 'feasible and realistic' 1940 weights are: aircraft - 45 per cent, tanks - 23 per cent, guns - 23 per cent, ammunition - 9 per cent.

air munitions *at current prices*. This price set may or may not be inconsistent with that underlying the four subindices.

What is the evidence for this? Table 2 compares the *Istoriya* index, recalculated with 1944 as the base year, with an official index of defence commissariat (NKO) expenditure on munitions. (This excludes only naval munitions, procured by the commissariat for the war fleet.) Except in 1940-1, the two indices move almost exactly in step.[5] The fit is too good to be a coincidence (however, I cannot explain the 1940 gap).

Two questions can now be asked about the four subindices with which the *Istoriya* index is associated. First, do they really measure production, rather than expenditure? Second, what price set was used to compile them?

I think it likely that the four subindices are genuinely based on production measures. They are explicitly classified by commissariat, that is, by production branch. While the behaviour of the *Istoriya* index can be clearly associated with an expenditure series, the same is true for only part of one of the four subindices.[6] Regardless of the

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5 This was drawn to my attention by Peter Wiles. I owe him special thanks for giving me access to the rare and invaluable *Finansovaya sluzhba* (1967), from which this and other evidence is derived.

6 The behaviour of the four production based subindices shown in Table 1 can be compared with indices of expenditure based classes of NKO munitions procurement

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Table 2. *NKO munitions expenditure at current prices, and the* Istoriya *index, compared*

Index	1940	1941	1942	1943	1944
The *Istoriya* index[a]	40	56	74	89	100
NKO expenditure on munitions at current prices	33.0	54.6	76.8	89.4	100.0

Source: For the *Istoriya* index see Table 1. For the index of NKO munitions expenditure see *Finansovaya sluzhba* (1967), 66. For ease of comparison both indices are recalculated to show 1944 = 100.

Notes:

a When the *Istoriya* index is regressed against the NKO expenditure index over 1940-4, with the latter as the independent variable, the regression is highly significant, and the constant term is not significantly different from zero at the 10 per cent level. When the constant term is dropped, the regression is significant, and the regression coefficient is insignificantly different from one, at almost any meaningful level.

consistency or otherwise of the underlying price set, this would be sufficient to explain some discrepancy between the four subindices and the *Istoriya* index.

Reported Soviet munitions production and expenditure could be expected to diverge for more than one reason. To begin with, munitions produced might have exceeded munitions utilised because of the inclusion of defective products in reported output. However, given the Soviet system of military controls on quality in munitions factories (discussed in more detail below), this source of divergence should have been less than in other sectors of the Soviet economy.

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for 1941-5, derived from Doe (1982), Table 4. For comparability all are expressed in terms of 1944 = 100. The one congruence is found in the indices of tank production and procurement, 1943-5:

	1941	1942	1943	1944	1945
The Istoriya *subindices:*					
Aircraft industry	53	75	93	100	74
Tankbuilding industry	38	62	79	100	93
Armament industry	70	93	97	100	76
Ammunition industry	49	70	85	100	55
Indices of current NKO expenditure:					
Air armament	71	79	105	100	79
Tank armament			81	100	95
Vehicles and tractors			60	100	47
Gun armament (including ammunition)	52	78	88	100	67
Other	106	129	124	100	65

Another source of a production-expenditure gap was imported goods. Wartime munitions production fell increasingly below expenditure after 1941 as the Soviet Union became a net importer of war goods. Imported munitions were priced in domestic roubles and charged against the defence budget, and this would cause further divergence of expenditure series from production series.

Lastly, the expenditure classification of NKO munitions procurement used at the time was more comprehensive than the classification of munitions output by production branch. On the production branch basis used in war time, ground and air munitions meant the aircraft, armament and ammunition industries, the tank industry (after September 1941) and the industry for mortar armament (after November 1941).[7] In contrast, ground and air munitions expenditure comprised not only air armament, tank armament, and artillery armament (including gun ammunition, small arms and small arms ammunition), but also vehicles and tractors, and other armament ('technical and chemical stocks, means of communication, and many other objects ...').[8] Some of the latter were produced by civilian industrial branches and would have been excluded automatically from munitions output on a production basis. Clearly, the four subindices did not cover everything counted in total NKO munitions expenditure

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7 Harrison (1985), Appendix 4.

8 *Finansovaya sluzhba* (1967), 67-70.

- especially mortar armament, vehicles and tractors, and 'other' munitions.

It follows from these considerations that, if the *Istoriya* index was based on total NKO munitions expenditure, there was no reason for it to have an exact relationship with the four industry subindices.

At what prices were the four subindices calculated? It is certain that they were not compiled using genuinely fixed prices. However, this still leaves two alternatives - current prices, and the prices of '1926/27'.

It is possible that the four subindices measure reported output at current prices. The *Istoriya* index and the subindices diverge, but their divergence from each other is arithmetically small and is far less than their common divergence from series for reported physical output of munitions. Therefore, the subindices could have employed a price set similar to the *Istoriya* index, that is, transfer prices at current roubles. The discrepancy between them could be due entirely to the various sources of a production-expenditure gap.

However, '1926/27' prices cannot be ruled out. In theory these were product prices actually prevailing in 1926/27 or, for new products introduced after that year, notional prices based on 1926/27 factor input costs. However, new products were actually incorporated into the

'1926/27' price set at current prices, not the prices which would notionally have prevailed in 1926/27. Moreover, in munitions at least, the replacement of old products by new ones was quite rapid; as a result, by 1940 there were probably no products included in the '1926/27' price set which were actually priced in 1926/27. Thus the prices of '1926/27' amounted in reality to no more than a kind of moving average of new product prices over a past interval of variable length. The more rapid the diffusion of new products, the more closely would '1926/27' prices approximate to current prices.

In summary, the *Istoriya* index is based on the current rouble value of defence commissariat total expenditure on ground and air munitions. The four subindices which accompanied it are production indices covering a substantial subset (but not all) of the munitions subject to NKO procurement. The subindices may be calculated either at current prices or at '1926/27' prices which, in the case of munitions, may have come to nearly the same thing.

III

Munitions prices in wartime

If values lagged behind volumes, then rouble prices of Soviet munitions must have fallen substantially in war time. Here is something that we know about. Downward pressure on

munitions prices was initiated in March 1942 by trade commissar and deputy Prime Minister A.I. Mikoyan, who had been charged (one supposes) with investigating the dizzying rise in the cost of NKO procurements. He found multiple prices for identical products and huge price-cost margins in which NKO officials acquiesced. Meanwhile unit costs in the munitions industries were falling smartly, mainly because of the transition to serial production.[9]

According to Voznesensky, the prices of defence industry products in 1942 had fallen to 72 per cent of the 1940 level.[10] The evidence of munitions prices used below (see Appendix A) shows further falls in 1943 and 1944.[11] Another source of information is Soviet financial estimates of cost savings accruing in each year of the war as a result of buying this year's output at this year's prices rather than last year's prices. These can be compared with each year's total cost of munitions procurement to yield a chained Paasche index of prices for ground and air

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9 *Finansovaya sluzhba* (1967), 78-9.

10 Voznesensky (1948), 102.

11 Bergson (1961), 74 and Appendix E, reckoned 1944 munitions prices at above the 1942-3 level and only 20 per cent below the 1940 level. This figure seems arbitrarily conservative. Also arbitrary, but in the other direction, is the estimate of Krylov (1985), 34, who suggests that during the war the wholesale prices of 'the most important types of weapons and ammunition' fell by more than half. The basis of Krylov's statement may have been casual inspection of the general time trend of the somewhat unrepresentative sample of munitions prices shown in Appendix A.

munitions, with a 1944 figure of 69 when 1941 = 100.[12] (An index of naval munitions prices, also chained back to 1941, equals 79 in 1944.[13]) It would probably be appropriate to assume that the general level of munitions prices did not change significantly between 1940 and 1941. Therefore, these

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12 This is calculated as follows. Total munitions expenditure of the defence commissariat in period n, in billions of current roubles,

$$E_n = \Sigma p_n q_n$$

is derived from the budget's defence allocation in each year, the proportion absorbed by munitions expenditure and the index of munitions expenditure given in *Finansovaya sluzhba* (1967), 66. See also Doe (1982), Table 4. The annual savings attributable to price reductions over the previous year, also in billions of roubles,

$$S_n = \Sigma p_{n-1} q_n - \Sigma p_n q_n$$

is found in *Finansovaya sluzhba* (1967), 80, 84, 86, 87. For each year a Paasche index of change in prices over the previous year is obtained from:

$$P_n = E_n/(E_n + S_n)$$
$$= \Sigma p_n q_n / \Sigma p_{n-1} q_n$$

and the indices are chained by multiplying them together as follows:

	1941	1942	1943	1944	1945
E_n	24.2	34.0	39.6	44.3	31.6
S_n		10.0	3.5	1.1	1.2
P_n	100	77	71	69	67

The price index finds the following confirmation. According to *Finansovaya sluzhba* (1967), 87, the total saving from price reductions through the whole war amounted to 50.3 billion roubles. This compares with a saving of 51 billion roubles implied from my table, when we calculate the sum of $[(E_n/P_n) - E_n]$ over 1942-1944 plus one third of $[(E_n/P_n) - E_n]$ for 1945.

13 *Finansovaya sluzhba* (1977), 354.

1944 index numbers probably indicate the change in munitions prices over 1940, as well.

The official index of reported NKO expenditure on munitions shown in Table 2 can be divided by the ground and air munitions price index. The result is a chained Laspeyres index of real expenditure on ground and air munitions. In 1944 it stands at roughly 4.4 times 1940 expenditure. We would expect this to indicate an upper limit on an index number for total munitions production in 1944 for two reasons. First, it includes imported munitions, which grew from a nil quantity in 1940 to a significant quantity in 1944. Second, it excludes naval munitions, the real output of which fell between 1940 and 1944.

We can almost certainly do better than this, however, by producing a new index of the volume of total munitions produced. We can base it on available physical product series and published information about rouble weapons prices and expenditure shares in different years. We can take into account the fluctuating supply of naval munitions - the only line of Soviet defence output to decline during the war years. We can also examine the sensitivity of our estimates to whether 'early' or 'late' prices and values are used to weight the index.

IV

Reliability of physical product series

Before arriving at a new munitions index, we have to satisfy ourselves as to the reliability of its statistical foundations. How trustworthy are the available time series for physical output of tanks, planes, guns and shells?

A Soviet historian, B.V. Sokolov, has recently expressed distrust on the following grounds. Assuming their reliability, Soviet production figures for combat aircraft and armoured fighting vehicles may be used in combination with data on Soviet combat stocks and imports to estimate Soviet losses of these munitions in each period of the war.[14] He then compares Soviet equipment losses estimated in this way with German losses on the eastern front. He finds that estimated Soviet losses far exceeded German losses over equivalent periods, regardless of whether Soviet forces were losing or winning the war, often by a factor of two or three to one, occasionally by more.

Sokolov ascribes a part of the excess of estimated Soviet over German losses to the same Stalinist deformations in the military sphere which were associated with heavy

14 Sokolov (1988), 123. Define S_n as the level of combat stocks at the end of period n, and assume that there are no other stocks held in the rear or in reserve; the number of units produced during each period is given by Q_n, imported units by IM_n, and the number lost by L_n. Then:

$$L_n = Q_n + IM_n - (S_n - S_{n-1})$$

expenditure of soldiers' lives - excessive centralisation and despotic use of authority, unthinking obedience, the low valuation of life itself in the wake of the mass repressions of the 1930s. However, he judges that it is impossible to ascribe all the estimated disproportion to such factors. He believes the Soviet losses estimated in this way are implausibly high; he concludes that the fault lies with the underlying production data, which must be exaggerated. The contribution to Soviet victory of the Soviet munitions industries should be downgraded, although not excessively (that of the Soviet military should presumably be upgraded correspondingly).

I find this chain of reasoning doubtful. There are significant problems of methodology involved in the estimation of losses by Sokolov's route, but they are not conclusive.[15] For the sake of argument, therefore, let us take for granted that when Soviet munitions losses are

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15 Hidden assumptions are made about initial reserves and rear formations, and the change in their level in each period of account, and about noncombat losses. At the same time, it is true that the possibility of bias introduced as a result of hidden assumptions may diminish with the length of the accounting period. In the long run, both imports and changes in combat and reserve stocks were small relative to output, and it is output which therefore dominates (in an accounting sense) the determination of losses. Over the period of the war taken as a whole, these are unlikely to be significant sources of bias. The relative importance of combat and noncombat losses, however, will remain undetermined. For further discussion of this methodology see Harrison (1985), 110-15 and 256-66, where Soviet wartime losses of combat aircraft, armoured fighting vehicles and guns are similarly estimated.

estimated on the basis of production series they look disproportionately high. Is this unbelievable?

Modern Soviet military commentators do not find disproportionate rates of combat expenditure of Soviet munitions in World War II implausible. According to Vitalyi Shlykov, the Red Army began the war with a potentially decisive tank superiority, and wasted it as a result of strategic and logistic errors. Excessive losses arose in the early period of the war because of the incorrect use of tanks, deficiencies of leadership and the lack of spare parts. The wasteful deployment of tank units continued through 1942; even after 1943 when fully motorised and independently operating tank formations were created they continued to be used inappropriately, for example for assaults on large cities, right through 1945. As a result 'the Soviet tank forces suffered impossibly heavy losses throughout the war.'[16]

Sokolov, however, does not believe his own estimates of Soviet munitions losses, and considers that they are too high. He believes that numerical advantage must have reduced

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16 Shlykov (1988), 112-13. My thanks to Julian Cooper for this reference. Shlykov in turn refers to direct military estimates of average monthly permanent losses of aircraft, tanks and guns on the front line, given in *Voennaya strategiya* (1963), 427 as follows: aircraft - 21 per cent, tanks - 19 per cent, guns - 9 per cent. It is true that these are substantially lower than the equivalent rates implied by Sokolov and estimated by Harrison (1985), 265, using the same methodology as Sokolov. It is possible, however, that the military estimates refer only to combat losses.

Soviet losses below the German level after 1942. If estimated losses are too high, the reason must be that reports of munitions output were exaggerated. He considers that production was exaggerated first of all at the enterprise level:

> Inflated reports [*pripiski*] - a defect inherent in our national economy as in the prewar, so in the postwar period, were apparent also in war time when obligations were often handed down to enterprises subject to shortage of resources for their fulfilment and without taking account of real possibilities. The arbitrary administrative principle was triumphant, and on the fulfilment of these often unbalanced plans hung the fate, in the literal sense of the word, of enterprise leaders. Under such circumstances inflated reports were an inevitable evil.[17]

Personally I do not agree, and I tend to evaluate positively the reliability of Soviet data for munitions output in physical units. This is for two reasons. First, a military inspectorate was already installed in Soviet defence factories in 1939, charged with control over both quantity and quality of munitions output.[18] This was a system of 'consumer sovereignty' unique to the munitions industries in the Soviet economy, which made it much more difficult for the defence factory to record fictitious

17 Sokolov (1988), 125.
18 *IVMV*, ii (1974), 189; Cooper (1976), 26-7.

output in comparison with its counterpart in the civilian sector.

Second, there was no obvious reticence of enterprises and ministries when plans failed, even in the most critical months of 1941-2. Plan failure was reported and not concealed. Underfulfilment of quarterly and monthly plans for shell production by wide margins was reported period by period in the second half of 1941. By December 1941 the reported output of aircraft was down to two fifths of ministerial targets, and that of aircraft engines was down to one quarter.[19] The existence of these reports is inconsistent with the view that industrial leaders inflated output returns to show 100 per cent plan fulfilment because their lives depended on it.

'We all know that the assignments are impossible', wrote one participant; 'if they can be met only by 75 per cent, there will be rejoicing and bonuses and Orders of Merit.'[20] In fact, some of the most important peacetime obstacles to the reporting of true output were absent. Norms and targets were set, but workers and managers alike were praised and rewarded for producing as much as possible, not for mechanically fulfilling the plan. Underfulfilment of the plan was less a source of disgrace than slacking and working below capacity. Mechanically fulfilling the plan did not

19 *IVMV*, iv (1975), 150-151.
20 Kravchenko (1947), 410-11.

guarantee immunity from inspection.[21] Traditional incentives to falsifying reports may have been to some extent neutralised.[22]

Clearly, many Soviet wartime economic series are in need of revision. I am inclined to expect that revision would result in big changes to agricultural data, and to the synthesised industrial and national economic series of which the *Istoriya* index is just one example. I would be surprised if physical output data required radical surgery, and am inclined to see the reported production of munitions in physical units as a relatively reliable foundation for what follows.

V

Five new subindices

The first result of the revision process is five new indices covering the wartime supply of aircraft, armoured fighting vehicles (AFV), armament, ammunition and naval munitions, 1940-4. They can also be extended back to 1937, accepting somewhat lower standards of coverage, detail and reliability. Sources and methods are shown in more detail in Appendices A, B and C.

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21 E.g. Kolotov (1976), 267.
22 Dyker (1987), 309.

I begin by describing the methodology underlying the subindices for the period beginning in 1940. This is the best documented period as far as munitions output in physical units is concerned, and it gives correspondingly reliable results in terms of index numbers.

For 1940 and the war years, three different methods are used. Available time series for physical output of aircraft, AFV and armament are valued on the basis of 1941 munitions prices (published or estimated) and added up to give series for total output of the industrial branch in 1941 roubles. The process is repeated using 1944 munitions prices. When divided by base year output, the result is two indices, one set to 1941 = 100 and the other set to 1944 = 100.

In the case of ammunition, there are no available prices for either 1941 or 1944, and anyway there is only one continuous time series denominated in physical units for the war years, showing the supply of 'shells and mines'. This series is assumed to be representative of the supply of ammunition as a whole. Therefore, the problem of weighting and adding up different series does not arise at this stage. Indices are generated with both 1941 and 1944 as base years but the difference is purely formal.

For naval munitions we face a choice between an index based on numbers of warships of the 'basic classes' completed in each year, or an index of current expenditure deflated by a chained index of procurement costs which can

be reckoned in terms of a base year either in 1941 or in 1944. For various reasons, I prefer the method of expenditure deflation.

The choice of naval index is awkward, and makes quite a lot of difference. The published series for warships of the 'basic classes' shows a continuous and dramatic fall in vessel completion year by year from 41 in 1941 to only 4 in 1944. In contrast the index of deflated naval munitions expenditure shows a substantially lower level of procurement in 1941-2 compared to 1940, then a recovery to the point where real 1944 expenditure stands at more than four fifths of the 1940 level.

In principle I would prefer unambiguous physical product series to expenditure series, however accurately deflated, for the foundations of a revised munitions index. In this case, however, I prefer deflated expenditure for two main reasons. First, I believe that the disastrous fall in warship completions would probably be misleading as a measure of naval munitions consumption. Although the Soviet war fleet played no strategic role in World War II, it played a major tactical role, especially in support of the ground forces. At some moments this tactical role could be decisive. In the winter of 1941, for example, the Baltic fleet's artillery was central to the defence of Leningrad. The acquisition of new ships became less important than their supply with naval guns, ammunition and other means of

war. The latter are captured by the method of expenditure deflation, but would be lost otherwise (for example, the artillery series used for my new 'Guns' subindex in Table 3 explicitly excludes naval guns).

Second, the only available means of weighting the index of naval munitions in relation to other subindices is the share of the war fleet in overall defence expenditures, either in 1941 or in 1944. This makes it impossible to use warship completions for a 1944 based index. For 1944 it would be completely unrealistic to ascribe a weight of 7-8 per cent of total munitions production to 4 ships, and the result would be an absurd downward bias to the new index.

It may be objected that 1944 expenditure on naval munitions was sustained above the level of domestic production by imports. This is undoubtedly true, but I do not believe the effect to be very significant. The share of vessels (including merchant vessels, not chargeable to war fleet expenditures) in the dollar value of United States Lend Lease shipments in 1944 was less than 6 per cent,[23] and was similar to the navy's share in overall defence spending. This suggests that any overstatement of naval munitions production in 1944 arising from the use of deflated expenditure will be minor.

The new subindices for 1940-4 are shown in Table 3. Also shown in the table are results of their extension back

23 Harrison (1985), 259.

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Table 3. *New subindices for ground, air and naval munitions, 1937-44*

Year	Air-craft	AFV	Guns	Ammun-ition	Naval munitions
			At constant prices of 1941:		
1937	29	15	13	13	68
1938	36	21	30	32	76
1939	68	28	44	29	109
1940	69	26	43	36	155
1941	100	100	100	100	100
1942	141	381	282	190	95
1943	186	375	288	310	120
1944	218	465	280	326	133
			At constant prices of 1944:		
1937	13	3	5	4	51
1938	16	5	12	10	57
1939	30	6	17	9	82
1940	31	6	16	11	117
1941	46	22	38	31	75
1942	64	82	102	58	72
1943	84	81	104	95	91
1944	100	100	100	100	100

Source: See Appendices B and C.

to 1937. Index numbers given for the period before 1940 are certainly less reliable than for the war years themselves. Before 1940 three of the five subindices (aircraft, AFV and ammunition) rely on a single series showing units produced under some heading which is assumed to be representative, and the aircraft series is inflated in the early years by inclusion of civilian types. Only the armament index maintains relatively full coverage before as after 1940.

The prewar subindex for naval munitions is based on an official index of shipbuilding industry gross output. The prices at which gross output is evaluated are unspecified, but possibly current. It is also inflated in the early years by inclusion of civilian types. It excludes naval munitions other than warships, but I do not consider this to be a source of major distortion under peacetime conditions. A case could be made for dropping the prewar years from the naval munitions subindex altogether, and simply assuming that the prewar supply of naval munitions grew in line with a weighted average of other munitions. In fact, its inclusion will not make much difference over the period 1937-40 when the supply of shipbuilding output shown in the industry subindex grew 2.3 times, compared to 2.5 times for other munitions types taken together. It is true that the year to year movement of the shipbuilding subindex is quite different from that of other subindices, but this is information which seems relevant and interesting.

Of course, even after 1940, the new subindices are still not perfect. They are based on 16 underlying time series (of which 15 show physical output of munitions, and one shows deflated munitions expenditure). Only seven out of the 16 are complete in the sense of every observation being based on official reports; five of the seven cover aircraft production. Out of 80 observations required (16 series times the five years of war), no less than 24 have been estimated or interpolated. All the estimated observations, however, are anchored in at least one other officially reported observation on either side (intertemporally and/or simultaneously).

For the war years, the best of the new subindices are those covering aircraft, AFV and guns. Least satisfactory is the ammunition subindex, which is based on a single physical product series. I am unable to judge precisely the reliability of the naval munitions subindex, but I am sure that the new index of total munitions output (presented below) is better for its inclusion. For the prewar years the only reliably based subindex is the one for guns. Two of the five, the prewar subindices for aircraft and naval munitions, certainly understate output growth before 1940 because of the inclusion of civilian types, the relative importance of which was greater in earlier years.

The most important and ineradicable common defect of the new subindices is their neglect of changing product

quality. This is taken into account only when qualitative improvement in weaponry resulted in the expansion of one measured line of output at the expense of another - for example, the growth of medium and heavy tank output relative to that of light tanks. Otherwise it is entirely ignored. Undoubtedly the Soviet fighter-bomber, tank and gun of 1944 were very different products from those which took the field in 1941. I cannot myself find any way of taking this systematically into account. Nor do I find any solution to this problem in statistical work on the munitions production of other countries in World War II. Thus, the new subindices still do not pretend to measure anything more than the volume of output in a relatively crude sense, and represent a lower bound on the true (quality adjusted) growth of munitions produced.

Still, I believe that for the period 1937-44 the problem of qualitative change in weaponry is not so great as to destroy the value of a new index of munitions output based on change in the numbers of units produced. It is true that, if we were to try to extend the index further back into the prewar decade, the rapid qualitative improvement then taking place in military technology would begin to represent an uncontainable problem. This is why I take no earlier year than 1937 for the new subindices' starting point.

The extent of the new subindices' deviation from the old ones is quantified in Table 4. This confirms the utter unreliability of the old ones as guides to the volume of output.

VI

Weights for a new overall index

The new subindices can now be combined using appropriate expenditure weights. These weights are derived from expenditure shares as shown in Table 5. In contrast with NKO total expenditure on ground and air munitions, vehicles and tractors are excluded (but in war time these were mainly imported), and so are 'other' munitions ('technical and chemical stocks, means of communication', etc.). A more positive step is to include the supply of naval munitions.

The main unsolved problem associated with these weights is that in the original source expenditures on guns and ammunition are lumped together, and we do not know what weights to attach to guns and ammunition separately.

The structure of munitions output and expenditure in other countries involved in World War II can be examined in order to come closer to realistic Soviet weights for guns relative to ammunition. But the only helpful parallel is the German case; when the implicit weights of the Wagenführ

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Table 4. *The new and old subindices compared: 1944 as per cent of 1940*

Index	Air-craft	AFV	Guns	Ammun-ition	Naval munitions
The Istoriya *subindices:*					
	239	296	206	310	-
The new subindices:					
at 1941 prices	315	1771	652	902	86
at 1944 prices	323	1698	611	902	86

Source: Table 1, and calculated from Appendix B.

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Table 5. *Expenditure weights for the new index of total munitions output*

Per cent	1941	1944
Aircraft	34.3	30.0
AFV	12.0[a]	14.3
Guns and ammunition	40.8	48.4
Of which:[b]		
Guns	16.3	19.4
Ammunition	24.5	29.1
Naval munitions	12.9	7.3
Total	100.0	100.0

Source: *Finansovaya sluzhba* (1967), 67 gives shares of various types of ground and air munitions in total NKO munitions procurement in various years, as follows: aircraft armament, tank armament, artillery armament (including gun ammunition, small arms and small arms ammunition), vehicles and tractors, and other armament ('technical and chemical stocks, means of communication, and many other objects ...'). In the table these are adjusted (a) by exclusion of vehicles and tractors, and of 'other' armament; (b) by incorporating naval munitions using the weight of war fleet expenditures in defence spending as a whole, as reported in war budgets for which see Doe (1982), Table 4. For other detail see notes below.

Notes:

a For 1941 the source gives the joint share of tank armament, vehicles and tractors in NKO expenditure on ground and air munitions as 15.3 per cent. In 1943-5 when these shares were reported separately, the ratio of spending on tank armament to spending on vehicles and tractors varied between 1.04:1 and 2.1:1. In those years expenditure on motor vehicles was greatly augmented by import purchases. For 1941, when imported vehicles were insignificant and the domestic motor industry had been largely turned over to the production of weapons, I assume that the bulk of expenditure under the joint heading was allocated to purchase of tank armament.

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Notes to Table 5 (continued):

b In the source, 'artillery armament' includes ammunition. In the table I divide expenditure on guns from expenditure on ammunition in the ratio 2:3 in both 1941 and 1944. This is calculated so as to provide rough equality of 'real' spending (whether in prices of 1941 or of 1944) on guns and ammunition in 1942. This conforms with the following data showing production of ground and air munitions in 1926/27 roubles in 1942, taken from Kravchenko (1970), 203:

By industry:	*January:*		*July:*	
	Mn 1926/27 roubles	*Per cent*	*Mn 1926/27 roubles*	*Per cent*
Aircraft	591	24.8	1163	30.8
Tanks	496	20.8	537	14.2
Armament	676	28.4	1063	28.1
Ammunition	616	25.9	1020	27.0
Total	2379	100.0	3782	100.0

The similarity of composition of war production between July 1942 (in '1926/27' prices) and 1944 (in current prices, shown in the table) is accidental, the real structure in these two periods being quite different.

index are estimated, they show that the share of guns in German military output in the base period of January-February 1942 stood at 11 per cent, and that of ammunition at 22 per cent.[24] These shares varied thereafter within the narrow range of 11-14 per cent for guns and 24-26 per cent for ammunition in each full year, 1942-4. For the United States, in contrast, expenditure on ammunition was much less important, varying between only 5 per cent of the total munitions budget in 1941 and 13 per cent in 1945.[25] I assume that of these two Germany presents the closer parallel to the Soviet situation. (For the United Kingdom there is no separate indication of the weight of either guns or ammunition in war production or expenditure.)

Faced with such uncertainty I turn reluctantly to fragmentary data on the structure of Soviet munitions output in 1942 (January and July only), measured in the notorious rouble prices of '1926/27' which have been discussed earlier. These data are reproduced in a note to Table 5. They suggest that in 1942 there was a rough equality of 'real' output of guns and ammunition. In 1942, however,

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24 This is the outcome of regressing the Wagenführ index (as the dependent variable) against its eight subindices over 36 monthly observations. Estimated January-February 1941 weights are as follows: aircraft - 39.6 per cent, ammunition - 22.2 per cent, weapons - 11.3 per cent, ships - 11.2 per cent, motor vehicles - 8.0 per cent, tanks - 4.3 per cent, powder - 4.2 per cent, explosives - 0.4 per cent. All but the last two are significant at the 0.5 per cent level. The regression as a whole is an almost perfect fit - as it should be. For the index itself, see *Die deutsche Industrie* (1954), 178-81.

25 Calculated from Smith (1959), 5.

conditions of shell famine prevailed,[24] Table 3 above showing clearly that the output of ammunition was low compared to that of guns by the standards of other war years. Rough conformity of the expenditure weights presented in Table 5 with this picture of 1942 is achieved if we divide expenditure on guns from expenditure on ammunition in the ratio 2:3 in both 1941 and 1944.

VII

The new index of total munitions output

The revised index is shown in Table 6. There are two versions based on the relative munitions prices of 1941 and 1944 respectively. When the base year is 1941, the index shows that Soviet munitions output expanded rapidly in the last prewar years before slowing in 1939-40. On the outbreak of war, Soviet munitions output began to grow with still greater rapidity, even taking into account the early decline in output of naval munitions. The period of fastest growth was 1941-2 when real output doubled. Taking the war as a whole, the year of peak output was 1944. In that year munitions output stood at 4.35 times the 1940 level, and 10-11 times the level already achieved in 1937.[27]

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26 Yakovlev (1981), 84, 117.

27 The expansion of two and a half times over 1937-40 shown in Table 6 is just less than that estimated by Bergson (1961), 371, according to whom real Soviet munitions output in 1940 was 2.8 times the level of 1937. Bergson's estimate was based partly on official reports of production (measured in '1926/27 roubles'),

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Table 6. *The new index of total Soviet munitions output, 1937-44*

At prices of:	1941	1944
Index numbers		
1937	26	10
1938	37	15
1939	55	22
1940	63	25
1941	100	38
1942	199	73
1943	247	91
1944	273	100
1944 as per cent of:		
1940	435	400
1937	1062	979

Source: The new subindices shown in Table 3, summed using expenditure weights shown in Table 5.

Note: The impact of varying the base-year division of spending on guns from spending on ammunition, in the ratios of 3:2 or 1:4 (instead of the 2:3 used in Table 5), is calculated as follows, in percentages of the index numbers for 1940-4 shown in the table:

	1940	1941	1942	1943	1944
At 1941 prices:	± 0.9	0.0	± 3.8	± 0.7	± 1.4
At 1944 prices:	± 2.0	± 1.8	± 5.9	± 0.9	0.0

When munitions output is revalued in the prices of 1944, the picture changes only a little. The period of most rapid growth is still 1941-2, and the year of peak output is still 1944. Expansion in 1941-2 is estimated at just over 90 per cent; in 1944, peak output still stood at 4.0 times the 1940 level and 9-10 times the level of 1937. Thus, the use of 'late' prices makes the growth record look a little more modest, but the overall effect is small.

The range of estimates given in Table 6 for the growth of munitions output, 1940-4, falls just inside the upper limit set by real deflated NKO expenditure on ground and air munitions in 1944, estimated above at 4.4 times the 1940 level.

A note to Table 6 also shows that these results are not overly sensitive to substantial variation of assumptions about the relative weights of guns and ammunition. In Table 5 expenditure on guns was divided from expenditure on ammunition in the ratio 2:3 in both 1941 and 1944. Alternatively, spending on guns may be divided from spending on ammunition in the ratios of 3:2 or 1:4. When the base year is 1941, the only wartime index number to be seriously affected is that for 1942, when the extent of possible bias is shown to be ± 3.7 per cent. In other years the range of

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partly on reported budgetary appropriations. Some understatement of prewar munitions output growth is likely in Table 6 because of the inclusion of civilian aircraft production, relatively more important than combat types in the earlier years, and the very large weight of aircraft production in prewar rearmament.

error is less than one and a half per cent. When the base year is 1944, varying assumptions about the relative weights of guns and ammunition have greatest effect again in 1942 (± 5.9 per cent); in other war years the range of error is two per cent or less.

The behaviour of Soviet munitions output can be compared with the expansion recorded in some other countries. This is shown in Table 7. According to index numbers shown in the top half of this table, in the United States the production of armaments in 1944 was roughly 6.7 times the 1941 level. British munitions output is known to have peaked in the first quarter of 1944 at 6.5 times the 1939 (4th quarter) level; taking 1943 as the calendar year of peak output, the equivalent figure was an expansion factor of 6.0 times. In each case the expansion of munitions output from the outbreak of hostilities to the wartime peak was more rapid and compressed than that of Germany, where the index of munitions output shows peak output in 1944 at 6.3 times the level of 1938.

A similar increase in Soviet munitions output up to the 1944 peak (6.7 times) was probably achieved in the period from 1938. This was an interval similar to that required by Germany. The time taken partly reflects the fact that, like Germany, the Soviet Union was an early starter in the interwar arms race and had already built up a relatively high level of output in the late 1930s. By 1941, each

country had achieved a similar expansion over 1938. After 1941, however, the munitions indices of the two countries behaved quite differently. Soviet output surged ahead; Germany's late burst of effort in munitions production in 1943-4 came too late to reverse the outcome of the struggle.

The level of munitions output achieved by the warring powers in various years can also be compared. The index numbers shown in the top half of Table 7 can be combined with Raymond Goldsmith's very rough estimate of relative levels of munitions output of the great powers in 1944. This yields the figures in the bottom half of Table 7, which show each country's munitions output in each year in proportion to that of the United States in 1944.[28]

These show that, despite big differences in the scale and pace of prewar rearmament, by 1941 each of the four countries was producing munitions at roughly the same absolute level. This meant that Germany was already being outproduced by three to one (and neither Italy nor even Japan contributed much to offset this disproportion), but of course Germany was actively engaged on land with only one of the three future Allies. After 1941, the German disadvantage was compounded and multiplied. In 1942, even the weakened Soviet economy managed to outproduce Germany's war

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28 The results shown in Table 7 for years before 1944 differ significantly from those of Goldsmith (1946), 72, 74, because of big differences in the behaviour of the underlying index numbers. Goldsmith's findings have been aired recently in Harrison (1988), 172.

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Table 7. *The total output of munitions: the USA, UK, USSR and Germany, 1937-45*

	USA	UK	USSR	Germany
Index numbers, based on:				
	mid-1945[a]	Jan-Mar 1941[a]	1944	Jan-Feb 1942[a]
1937	–	–	10	–
1938	–	–	15	16
1939	–	17[b]	22	20
1940	7[c]	42[c]	25	35
1941	15	54	38	35
1942	53	86	73	51
1943	91	102	91	80
1944	100	100	100	100
1945	86[d]	–	–	–
Per cent of United States munitions output in 1944:				
1937	–	–	4	–
1938	–	–	5	6
1939	–	4[b]	8	8
1940	7[c]	11[c]	9	14
1941	15	13	13	14
1942	53	22	26	20
1943	91	26	32	32
1944	100	25	35	40
1945	86[d]	–	–	–

Sources: The United States index is calculated from constant price dollar values in Smith (1959), 5. The UK index is calculated from a quarterly index in Harrison (1989), Table 3. The Soviet index is taken from Table 6 above, and the German index from *Die deutsche Industrie* (1954), 191.

Other countries' 1944 munitions output as per cent of the 1944 munitions output of the United States is taken from rough estimates given by Goldsmith (1946), 71 as follows:

United States	100
United Kingdom	about 25
USSR	over 35
Germany	about 40

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Notes to Table 7:

a For ease of comparison, non-Soviet indices have been recalculated to show 1944 = 100.

b Fourth quarter of 1939 at annual rate

c Second half of 1940 at annual rate

d January-August 1945 at annual rate

industries. Thus, the table confirms that German failure to win the war in Russia by the beginning of 1942 was already decisive in her loss of control over the war's outcome.

In 1943-4, as Anglo-American resources were thrown into the balance, the German disadvantage became overwhelming in spite of increasingly frantic efforts. Of the weapons supplied by the three Allies after 1941, three fifths came from the war industries of the United States alone. Nearly a quarter was supplied by the Soviet Union, and the rest from Great Britain. However, Soviet munitions were also significant out of all proportion to their numerical weight because of their role in the destruction of Germany's fighting strength on land.

Appendix A. *Soviet munitions prices, 1941-5*

Table A-1.

	1941	1942	1943	1944	1945
Aircraft (thousand roubles):					
Il-4[a]	800	468	380	380	380
Pe-2[b]	420	353	265	265	265
Li-2[c]	650	510	424	424	
Il-2[d]		206.3[e]	168.5[f]		
AFV (thousand roubles):					
KV[g]	635	295	225		
T-34[h]	269.5	193	135	135	
T-34-85[i]			164	164	142
Guns (roubles):					
122 mm M-30 howitzer[j]	94000	39000	35000	35000	35000
PPSh machine pistol[k]	500	400	140	148	148
7.62 mm rifle[l]	163	120	100	100	100

Source: *Finansovaya sluzhba* (1967), 87 (except for the Il-2 assault aircraft, on which see page 84).

Notes:

a The Il-4 was a two-engined bomber with range of 3,300 km and bomb load of 1,000-2,500 kg.

b The Pe-2 was a smaller, faster two-engined bomber with 1,300 km range and 600-1,000 kg bomb load.

c The Li-2 ('*duglas*') was a two-engined transport aircraft, a Soviet copy of the famous Douglas DC-3 Dakota.

d The Il-2 was a relatively lightweight ground attack (*shturmovik*) aircraft.

e Multiple factory pricing of the Il-2 prevailed for much of the war. The figure given is the unweighted mean of 225, 203 and 191 thousand roubles.

f The unweighted mean of 175 and 162 thousand roubles.

g The KV (Kliment Voroshilov) tank was the basic Soviet heavy tank during 1941-3; the KV-1C (August 1942 onwards), lighter and faster than earlier models, with a maximum thickness of armour steel of 88 mm and a top speed of 43 kph, weighed 42.5 tons and deployed a 76 mm cannon. It was superseded in 1944 by the IS (Iosif Stalin) heavy tank.

h The T-34 was the workhorse of the armoured forces; a medium tank with a maximum thickness of armour steel of 52 mm and a top speed of 55 kph, it weighed 31 tons and deployed a 76 mm cannon.

i The T-34-85 was an upgraded version of the T-34 with a more powerful 85 mm cannon.

j The M-30 was a relatively light and modernised (1938) model gun, firing a 13-22 kg shell over a maximum range of 11.8 km, with superior armour piercing capability (up to 140 mm of armour steel at one km).

k The PPSh was the Soviet soldier's tommy gun.

l The 7.62 mm rifle was the basic Soviet infantry weapon, the equivalent of the British .303.

Appendix B. *New subindices of Soviet munitions output, 1940-4*

Table B-1. *Aircraft*

	1940	1941	1942	1943	1944
Output (number of units):					
Bombers[a]	3571	3748	3537	4074	4186
Transport[b]	1691	3091	3298	3744	5508
Fighters[c]	4574	7086	9924	14590	17913
Assault[c]	0	1543	8219	11177	11110
Trainers[c]	549	267	457	1260	1528
Prices of:	*Index numbers:*				
1941	69	100	141	186	218
(as per cent of 1940)	(100)	(144)	(204)	(268)	(315)
1944	31	46	64	84	100
(as per cent of 1940)	(100)	(147)	(208)	(273)	(323)

Sources: Output data are from Harrison (1985), 250. Rouble values for 1941 and 1944 are based on Appendix A as specified in the notes below.

Notes:

a These are valued at the unweighted average of prices of the Il-2 and Pe-2. Both of these were only medium bombers by Anglo-American standards, but the Soviet designed only one four engined strategic bomber in war time, the Pe-8, and I believe that it was produced only in small numbers.

b These are valued as if they were all *duglasy* (the Li-2).

c The only data on values of smaller aircraft types are the fragmentary data for the Il-2 in 1942-3 assembled in Appendix A. For their 1941 unit price is taken the 1942 average for the Il-2 as a ratio of the unweighted average of 1942 prices for all other aircraft listed in Appendix 2, multiplied by the proportional change in the unweighted average of prices for all other aircraft over 1941-2. For

1944 I take the 1943 average for the Il-2 as a ratio of the unweighted average of 1943 prices for all other aircraft, multiplied by the proportional change in the unweighted average of prices for all other aircraft over 1943-4.

Table B-2. *Armoured fighting vehicles*

	1940	1941	1942	1943	1944
Output (number of units):					
Heavy[a]	243	1326	4919	4847	6155
Medium[b]	115	2996	12351	12348	15681
Subtotal[c]					21836
Light[d]	2436	2268	6996	6894	7127
Total[c]	2794	6590	24446	24089	28963
Prices of:	*Index numbers:*				
1941	26	100	381	375	465
(as per cent of 1940)	(100)	(381)	(1449)	(1428)	(1771)
1944	10	23	84	83	100
(as per cent of 1940)	(100)	(365)	(1394)	(1374)	(1698)

Sources: Output data are based on Harrison (1985), 250, and rouble values for 1941 and 1944 are based on Appendix A as specified in the notes below.

Notes:

a For 1940-1, I take reported output of the KV. For 1942-3, I take reported total tank numbers produced multiplied by the 1941 proportion of KVs in the total. For 1944, I take reported numbers of heavy and medium tanks produced multiplied by the 1943 proportion of heavy tanks in this subtotal. Each unit is valued at the price reported for the KV; for 1944, I assume that the price of a KV would have remained at the same level as in 1943, as in fact happened for prices of the T-34 and T-34-85.

b For 1940-2, I take reported output of the T-34. For 1943 I take reported total tank numbers produced multiplied by the 1942 proportion of T-34s in the total. For 1944, I take reported numbers of heavy and medium tanks produced multiplied by the 1943 proportion of medium tanks in this subtotal. Each unit is valued at the price of a T-34.

c Reported output.

d Total tank numbers less medium and heavy tanks. Each unit is valued at half the price of a T-34.

Table B-3. *Guns*

	1940	1941	1942	1943	1944
Output (number of units):					
Artillery[a]	15300	42300	127000	130300	122400
Of which:					
Medium and heavy guns[b]	7183	18106	49100	48400	56100
Light guns[c]	8117	24194	77900	81900	66300
Mortars[d]	38500	52500	229900	69500	7100
Machine guns[e]	194700	275400	356100	458500	439100
Output (thousand units):					
Machine pistols[f]	81	99	1506	2024	1971
Rifles[g]	1461	2660	4049	3437	2450
Prices of:	*Index numbers:*				
1941	43	100	282	288	280
(as per cent of 1940)	(100)	(233)	(655)	(669)	(652)
1944	16	38	102	104	100
(as per cent of 1940)	(100)	(231)	(626)	(633)	(611)

Sources: Output data are based on Harrison (1985), 250, and rouble values for 1941 and 1944 are based on Appendix A as specified in the notes below.

Notes:

a From Harrison (1985), 250. Naval guns are excluded.

b 'Medium and heavy guns' had a calibre in excess of 76 mm. For 1940 I take all artillery multiplied by the 1939 proportion of medium and heavy guns in this total, where this proportion has first been corrected by addition of one third of the change

in the proportion of medium and heavy guns in all artillery taking place between 1939 and 1942. Let *A* stand for all artillery units and *MHG* for medium and heavy guns. In this case I estimate MHG_{1940} as equal to:

$$A_{1940} \times [(MHG_{1939}/A_{1939}) + \{(MHG_{1942}/A_{1942}) - (MHG_{39}/A_{1939})\}/3]$$

For the following year, I take MHG_{1941} as equal to:

$$A_{1941} \times [(MHG_{1939}/A_{1939}) + 2 \times \{(MHG_{1942}/A_{1942}) - (MHG_{39}/A_{1939})\}/3]$$

For 1942–4 I use reported output. Output is valued at the rouble price of an M-30 122 mm gun.

c All artillery less medium and heavy guns, valued at half the price of an M-30.

d Reported output, valued at twice the unit price of a PPSh machine pistol. This may seem a lot for a mortar, but the Soviet Army favoured heavy calibres.

e For 1940 I take reported 1939 output plus one third of the change over 1939–42 and, for 1941, plus two thirds of the change. For 1942–4 I take reported output. Each machine gun is valued at twice the price of a PPSh.

f Reported output, valued as the PPSh.

g For 1940 and 1942–4 I use reported output. For 1941 output is estimated by linear interpolation between 1940 and 1942. Each unit of output is valued as the 7.62 mm rifle.

Table B-4. *Ammunition*

	1940	1941	1942	1943	1944
Output (thousand units):					
Shells and mines[a]	24268	67079	127387	207737	218900
Base year:	*Index numbers:*				
1941 = 100	36	100	190	310	326
1944 = 100	11	31	58	95	100
(as per cent of 1940)	(100)	(276)	(525)	(856)	(902)

Source: Output data are based on Harrison (1985), 250.

Note:

a For 1940 I take the output of shells divided by the 1942 proportion of shells in the total output of shells and mines. For 1941-4 I take reported output. Aircraft shells are excluded.

Table B-5. *Naval munitions*

Index	1940	1941	1942	1943	1944
Expenditure estimate at current prices[a]	100.0	102.0	57.2	61.2	68.6
Utilised expenditure at current prices[b]	100.0	64.5	52.7	61.4	64.3
Chained price index[c]	(100)	100.0	86.0	79.1	75.2
Chained index of real expenditure on naval munitions:[d]					
1941 = 100	155	100	95	120	133
1944 = 100	117	75	72	91	100
(as per cent of 1940)	(100)	(64)	(61)	(78)	(86)

Notes and sources:

a For the index of expenditure on naval munitions at current prices in 1940 and 1942-4 see *Finansovaya sluzhba* (1967), 352. For 1941 I insert the index number for total war fleet expenditure estimates from page 334.

b For coefficients of naval munitions expenditure estimate fulfilment see *Finansovaya sluzhba* (1967), 337 as follows: 1941 - 63.2 per cent, 1942 - 92.2 per cent, 1943 - 100.3 per cent, 1944 - 93.7 per cent. For 1940 I assume 100 per cent fulfilment; this is a reasonable assumption given that in peace time defence expenditure plans were normally strictly carried out.

c This index is chained together from estimates of year on year change in prices of naval munitions, in *Finansovaya sluzhba* (1967), 354. I do not know whether the given movement of prices in each year

is weighted by this year's or the previous year's quantities. It probably does not matter very much.

d Utilised naval munitions expenditure at current prices, divided by the chain index of prices, and expressed in terms of various base years.

Appendix C. *Extending the new subindices of Soviet munitions output back from 1940 to 1937*

Table C-1. *Soviet munitions output in physical units and index numbers, 1937-40*

	1937	1938	1939	1940
Output (number of units):				
Aircraft (including noncombat types)	4435	5467	10382	10565
Tanks	1559	2271	2950	2794
Guns				
- medium and heavy	1705	5214	8863	7183[a]
- light	3768	7126	8485	8117[a]
- mortars	1600	1200	4100	38500
- machine guns	42000	77000	114000	194700[a]
- machine pistols	1000	1000	22000	81000
- rifles	578000	1175000	1503000	1461000
Shells	4889000	12435000	11242000	14000000
Output (1937 = 100):				
Gross output of the shipbuilding industry	100	112	160	228
Indices:				
1941 = 100				
- aircraft[b]	29	36	68	69
- AFV[b]	15	21	28	26
- guns[c]	13	30	44	43
- ammunition[b]	13	32	29	36
- naval munitions[d]	68	76	109	155
1944 = 100				
- aircraft[b]	13	16	30	31
- AFV[b]	3	5	6	6
- guns[c]	5	12	17	16
- ammunition[b]	4	10	9	11
- naval munitions[d]	51	57	82	117

Source: For ground and air munitions, output data are from Harrison (1985), 250 except as specified below. For the shipbuilding industry gross output index see Kravchenko (1970), 85.

Notes:

a See corresponding entries in Appendix B.

b An index based on the number of units produced is chained onto the appropriate subindex entry for 1940, shown in Table 3 above.

c This is an index calculated at the same constant prices and based on data of the same coverage and provenance as those described in Appendix B, Table B-3.

d The industry index of gross output, chained onto the subindex entry for supply of naval munitions 1940, shown in Table 3 above.

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