Industrial mobilisation for World War II: a German comparison*

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In World War II, the Soviet mobilisation of industry appears to have been more successful than the German. Yet in terms of prewar resources and ex ante mobilisation potential there is no obvious reason why this should have been the case. In production, resources, and mobilisation preparations there were many similarities. The obvious differences were mostly to the Soviet disadvantage. Yet the Soviet economy produced weapons on a larger scale than Germany, and more of Soviet war production came earlier in the war. How can this be explained?

By a process of elimination, I arrive at the factor of mass production. In *Why the Allies won*, Richard Overy emphasised the role played by 'American and Soviet productionism' in contrast to 'Germany's bureaucratised economy'. Drawing on the copious evidence of memoirs, official reports, and war production statistics, he wrote:

> No war was more industrialised than the Second World War. Factory for factory, the Allies made better use of their industry than their enemy.[1]

German failure was to be explained, Overy argued, by a lack of commitment to mass production. The purpose of this chapter is to try to isolate more precisely the significance of Soviet mass production. The origins and consequences of production systems are a multi-faceted topic, the dimensions of which are gradually becoming clearer with new research. Some additional historical factors can be explored, if not yet definitively.

The Soviet advantage in war production

To begin with, in what sense was Soviet war production more successful? I have in mind that Soviet industry was mobilised more

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* This paper appeared as a chapter in *The Soviet Defence Industry Complex from Stalin to Khrushchev*, pp. 99-117. Edited by John Barber and Mark Harrison. Basingstoke and London: Macmillan Press, 2000.

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[1] Overy (1995a), 207.

rapidly than German industry, showed a different time profile of output, with a higher proportion of cumulative output earlier in the war, and secured higher flows of weapons at all stages. Both the overall volume and the phasing of output were significant in their own right, but I do not mean to imply that either was decisive on its own. The Soviet Union was not Germany's only enemy; had German war production accelerated faster, or achieved a higher overall volume, Germany might still have been defeated, whether by the Soviet Union or by a combination of other powers. Nonetheless it is true that the struggle on the eastern front was very evenly balanced for a period of some 21 months from the autumn of 1941 to the summer of 1943. For most of this time the Soviet Union was being defeated, and there was several points at which outright military and economic collapse could not be ruled out. Therefore the comparative mobilisation of industry was certainly of very great importance.

Annual figures and cumulative totals of war production of the two powers in physical units are shown in table 5.1. It is notable that overall Soviet production outweighed that of Germany in virtually every item listed; only in shipbuilding did Soviet industry fail to compete. More remarkable is the fact that the Soviet advantage was at its greatest in 1942; just when its struggle against the Wehrmacht for the military advantage was at the most intense, the Red Army was receiving combat aircraft at twice the rate of delivery to the enemy, and 3 or 4 times the flow of most other types of ground forces' armament. After 1942 the pace of German war production accelerated, but Germany's context had already changed to one of commitments multiplying out of control and an inexorable unfolding of defeat.

This Soviet-German contrast could be set in a more general comparison. Good serial data for overall war production are available for five cases of great powers in modern great wars: the Soviet Union, the United States, and Germany in World War II, and Britain in both World Wars. The acceleration of war production is a tricky thing to capture objectively since obvious measures such as growth rates and percentages of cumulative output are heavily dependent on the degree of prewar mobilisation and the frequency of sampling relative to the duration of the war. The most appropriate general model seems to be that of the logistic curve, the parameters of which will reflect the rapidity with which the mobilisation potential is saturated. In each of the five cases indicated the war production measure may be indexed as percentages of peak output. I then look for the logistic curve which best describes the path of war production prior to the wartime peak.

Results are shown in table 5.2 and graphed in figure 5.1. For four cases the logistic model is found to be robust. The estimated *b* parameter of the logistic curve allows us to rank the four in order of diminishing 'steepness' of the war production curve as follows: the United States, the United Kingdom in World War I, the Soviet Union, and the United Kingdom in World War II. The differences among them, however, are not great as a visual check with figure 5.1 confirms. The truly exceptional case is that of Germany, where a match to the logistic curve is found only with some difficulty, and two of the three parameters are not statistically significant. A fit can be found only on

the implausible basis that, at its wartime peak, German war production was just beginning the slow ascent of a logistic curve of immense height.

One might more simply conclude that, on this evidence, Germany's industrial mobilisation was a comparative failure. The approach to the peak was too gradual. A logarithmic scale would show little change in growth rates in 1942 with the supposed transition from Göring's regime of 'incompetence, arrogance, and egotism' to the 'production miracle' stemming from Speer's policies of rationalisation; if anything, after the relative stagnation of 1941, the Speer reforms simply pushed German war production back onto the gradually rising trend already established in the period from late 1939 to late 1940.

In summary, the Soviet Union outproduced Germany in all branches of war production other than shipbuilding in World War II. Soviet production superiority was especially marked in 1942. Despite the fact that this was a war which German leaders had planned, and which took Soviet leaders by surprise, and despite the burdens imposed by Germany's deep penetration of Soviet territory, Soviet industry was mobilised more rapidly than German industry. The Soviet Union's war production was already within 5 per cent of its peak in the last quarter of 1942, a full 18 months before Germany's began to crest.

It used to be argued that this was simply Hitler's clever plan; the slow growth of German war production in the period 1939-41 was chiefly attributable to a self-imposed limitation of demand. Nazi leaders intended to win Germany's wars quickly and without major expenditure of munitions, which would have required cutbacks in civilian consumption and an early imposition of strict discipline on the mechanisms for resource allocation.[2] This view is now recognised to be defective. Richard Overy has shown that in the period 1939-41 German civilian consumption was significantly repressed; Hitler allocated major resources to war production and investment in autarky, and demanded a strong acceleration in the pace of war production. The only thing that went wrong with this programme is that the increase in war production did not materialise. Instead, productivity fell.[3]

Thus the main difference between Soviet and German industry in terms of wartime outcomes is that in the period 1941-3 Stalin's programme for the procurement of munitions was more successful than Hitler's. Below I investigate various hypotheses as to why this should have been the case. Taking them In order, I rule out various possibilities -- that Soviet industry had a greater mobilisation potential arising from superior prewar productive capacity or productivity, a more advantageous resource environment, and prewar mobilisation plans and procedures. The answer lies by default in wartime economic management of both demand and supply side factors.

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[2] See for examples Klein (1959); Milward (1965).

[3] Overy (1994), 250-4, 344-9.

Overall production and productivity

On the eve of World War II the Soviet and German industrial sectors were of comparable size in terms of workforce, Of course in overall employment terms the Soviet Union was much larger. As table 5.3 shows, Germany's employed population was just less than half the size of the USSR's. Almost all the difference, however, is accounted for by the agricultural sector.In fact, the nonagricultural workforces of the two countries were very similar in size: 29.2 million in Germany, 32.5 million in the USSR. The table also shows that numbers employed in each country in industry, construction, and transport were quite similar (18.6 million in Germany, 20 million in the USSR). However, the Soviet Union had substantially larger numbers engaged in transport, which no doubt reflected the country's greater territorial extent; and substantially fewer engaged in artisan production. The latter imbalance is explained in part by the suppression of small rural industries in the course of collectivising agriculture ten years previously.

The levels of development of the two countries' industrial sectors (and therefore the volumes of output) were probably very different, although the computation is complicated and must use a chain of binary comparisons in which the Soviet relativity is the weakest link. According to Stephen Broadberry, output per worker in German manufacturing in 1937 was at virtually the same level as in the UK, while US manufacturing output per worker was just over twice the British level.[4] At the beginning of the 1950s Walter Galenson carried out a binary comparison of Soviet/US gross industrial output per worker in 1936-9 and arrived at a figure of 40 per cent; combined with Broadberry's figures, this would suggest a prewar Soviet/German productivity ratio of roughly 80 per cent or a little less.[5] A similar ratio is implied for total output of industry since the workforces in the two countries were of similar size. But a more recent study by Remco Kouwenhoven (which involves backward extrapolation from a binary Soviet /US comparison of gross industrial output per hour worked for 1987) is much more pessimistic, giving 21 per cent in 1937 falling to 10 per cent in 1940.[6] The Soviet/US ratio fell towards World War II because US productivity gains coincided (as we shall see) with a Soviet productivity setback. But the Soviet/German ratio probably did not deteriorate so sharply. Still, Kouwenhoven's figures combined with Broadberry's point to a prewar Soviet/German productivity ratio of at most 40 per cent.

When synthetic comparisons are difficult, it is commonplace to turn to indirect, usually physical indicators. A few are collected in table 5.4. From a Soviet source (although not, originally, intended for wide circulation), they present a relatively favourable picture, suggesting

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[4] Broadberry (1995), 83.

[5] Galenson (1953).

[6] Kouwenhoven (1996).

that Soviet prewar industrial production was much more than 40 per cent of Germany's; but they also indicate (as one would expect) that the Soviet advantage was greater in basic materials, fuels, and energy, than in more highly fabricated products. However, such comparisons are almost always biassed by missing products in ways which are not always immediately apparent. The source cited in the table draws our attention to one which would be counted to the Soviet advantage -- the fact that the Soviet Union produced oil, where Germany did not. On the other hand, the table entirely ignores fabricated products other than industrial machinery, especially those important for transport, communications, information, and consumption, in which Germany certainly had the advantage. Thus no firm conclusions may be drawn from the table. Certainly it does not justify any greater optimism about the production potential of Soviet industry than the measures suggested by Kouwenhoven.

It is worth adding that the impact of the first years of conflict would swing the overall balance further in Germany's favour. Territorial expansion would add the industrial assets of much of continental Europe to Germany's side. Enemy occupation would subtract significantly from Soviet production capacities. The occupation of industrialised Europe (but probably not of the agrarian territories of eastern Europe and the western USSR) would be a real gain for Germany, outweighing the costs of aggression.[7] On the other hand, Allied bombing later in the war would force German production below its maximum potential.

The resource environment

To evaluate the potential of industry for further mobilisation it is necessary to consider not only its initial stocks and their utilisation, but also its wider context. Did the larger Soviet nonindustrial population and territory constitute a superior mobilisation reserve for Soviet industry?

In some obvious sense the answer is yes. The Soviet territorial expanse, blessed by rich deposits of minerals and materials, was nearly 50 times Germany's. The German density of settlement was 16 times that of the USSR.[8] Thus the Soviet balance of natural resources to population, and still more so to industrial workers, was relatively advantageous. In the same spirit there was some obvious sense in which the 49 million Soviet agricultural labourers constituted a much larger reserve for industry than the 11 million German farm workers.

However, the real mobilisation value of these Soviet human and material reserves was much less than the mobilisation value of the quantitatively more restricted numbers of Germans and more limited German territory. This was because of low levels of nonindustrial productivity and economic integration. The mineral resources were

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[7] Liberman (1996), 36-68.

[8] Harrison (1996), 10.

inaccessible or otherwise difficult to exploit without major investments in transportation and complementary services. The agricultural workers were locked into low-productivity employment from which they could not be easily extricated in case of need.

Table 5.5 shows some significant differences between prewar Germany and the Soviet Union in regard to agriculture. In Germany agricultural achieved half the productivity of nonagricultural workers (when calculated at German domestic prices). In the USSR farm workers' productivity was only one third (in Soviet prices) of the level achieved by nonagricultural workers, which was itself only a small fraction of the productivity standard set by German nonagricultural workers. Therefore it took nearly three fifths of the Soviet workforce to feed Soviet citizens to rather lower dietary norms than were achieved in Germany by one quarter of the German workforce (aided, it is true, by limited food imports).

Superficially this could appear to the Soviet mobilisation advantage. Suppose (as was probably the case) that not only the average but also the marginal product of labour was higher in prewar industry than in agriculture.Then, if wartime output is measured at constant prewar prices, a redistribution of labour from agriculture to industry will result in a small loss of real agricultural output more than compensated by a large increase in the real output of industry. Food supplies do not deteriorate by much, there is substantial growth of war production, and total output and productivity improve. The problem here is that prewar prices do not correspond to wartime utilities. The prewar Soviet Union was a low-income country where the marginal utility of food was relatively high and would rise steeply with wartime deprivation. There was much less scope for belt-tightening than in Germany. Therefore, wartime labour shortages were soon felt just as acutely in agriculture as in industry, and the mobilisation of labour out of agriculture was quickly followed by reverse movements.

One further possibility which might be mentioned is that Soviet industry was better placed than German industry in wartime because of supplies of forced labour. However, the evidence does not support this view. By 1944 3.5 million foreign labourers and prisoners of war were employed in German war production (one third of the munitions workforce) compared with half a million in 1941.[9] In contrast, in 1942 when Soviet war production was already near its peak, of 853 000 workers mobilised into the defence industry only 68 000 were forced labourers of the 'NKVD special contingent'.[10] This is not to say that the Stalinist regime did not possess and utilise sweeping powers of coercion over the working population, and it is clear that the defence industry workforce was strictly regimented.[11] However, forced labourers were more likely to be engaged in construction, logging,

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[9] USSBS (1945), 214

[10] RGAE, f. 4372, op. 42, d. 986, l. 118

[11] Barber and Harrison (1991), 163-7.

mining, and farming than in industrial production, and their total (counting prisoners in GULAG camps and colonies and 'special settlers' in internal exile) was less than 2 million in 1944 and did not exceed 3 million at any point in this period.[12]

In summary, from the point of view of resources and productivity Soviet industry was generally worse placed than German industry for war mobilisation. The obstacles facing it were twofold. One was the legacy of relatively low productivity in industry itself, stemming partly from an historical capital accumulation deficiency, partly from inefficient utilisation of capital assets and technological lag. The other lay in a poorly integrated, low-productivity nonindustrial environment.

Mobilisation preparations

The scope for wartime mobilisation depended not only on existing overall resources but also on specific preparations. The extent of prewar mobilisation and contingency planning would prove very important in preparing industry for war production and more far-reaching mobilisation tasks. Here there are notable similarities between German and Soviet industry in the degree of preparation.

First, by 1940 both countries were producing munitions on a comparable scale. According to my own previous estimate, in 1940 the Soviet Union was slightly ahead in overall terms. This assessment looks to be confirmed by the figures shown in table 5.1, which shows Germany to have been lagging somewhat in all areas except naval armament; when qualitative differences (especially for aircraft) are taken into account, however, the extent of the German lag was probably less than would appear.

Second, it is apparent that in the prewar years both countries had made major investments not only in specialised munitions capacities but also in the supporting facilities which would guarantee domestic supplies of industrial materials for war. In Germany the core tasks of the second Four-Year Plan of 1936-40 administered by Hermann Göring were the substitution of domestic for imported iron ore, of hydrogenated coal for imported oil, and of synthetic for imported natural rubber. These programmes took up 60 per cent of Germany's industrial investment in 1937-9; if aircraft and shipbuilding are included, the proportion rises to 70 per cent.[13]

The common stress on heavy industrialisation and a military-industrial build-up in Soviet interwar economic development is almost too well known to require documentation. Between 1928 and 1940 the fixed capital stock in Soviet machine-building and metallurgy grew by more than eight times, in contrast to relative stagnation for consumer goods, agriculture, and housing.[14] By the mid-1930s producer goods

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[12] Harrison (1996), 269.

[13] Overy (1994), 263.

[14] Hunter and Szyrmer (1992), 44-5.

(including defence industry) were taking 85 percent of industrial investment.[15] The share of the defence industry itself in industrial investment rose slowly at first from 3.3 percent in 1928/29 to 7.8 percent in 1932, and eventually to more than 30 percent in the national economic plan for 1941.[16]

Third, German and Soviet industrial leaders had made significant commitments to further mobilisation planning. Here quantitative comparisons are hardly possible. Serious mobilisation planning began in Soviet industry in the early 1930s (see chapters 2 and 3); soon it was stimulated by incoming intelligence of the progress in mobilisation planning being made in Germany. Through the 1930s a series of industry-wide mobilisation plans was adopted, and was reflected in a ceaseless cascade of lower level mobilisation plans and assignments which flowed down the ministerial hierarchies to industrial establishments. Of course there were defects of commission and omission, and it was hard to maintain a sense of reality.

On the other hand the quality of German mobilisation planning was probably lower than appeared to easily-impressed Russians (see chapter 11). As late as August 1939 the high command of the Wehrmacht was complaining that mobilisation plans were complete only for the steel, chemical, and synthetic oil industries (essentially those covered by the Four-Year Plan). In coal mining and machine tools they were in preparation, and in the rest of manufacturing industry they simply did not exist.[17] It seems likely that the leaders of both countries, from Stalin and Hitler down, consistently believed themselves to have more time to complete their war preparations than would actually be available, and this belief was common and shared.

Fourth, as of 1940 both countries' industries contained a significant slack of poorly utilised resources in reserve. There was no visible unemployment of either labour or fixed capacity. Instead, the reserve was being formed by declining productivity. Table 5.6 shows that in the period 1939-41, productivity in the German munitions industry fell by one quarter. Richard Overy has commented that 'the large increase in the proportion of the industrial work-force involved in military production did not produce a proportionate increase in military output'; in the aircraft industry the workforce increased by 50 per cent, but the output of finished aircraft by only 15 per cent.[18]

No such indicators are available for the Soviet defence industry before the war; industry as a whole, however, certainly suffered a serious negative shock to productivity at this time. Table 5.7 shows that output per hour worked in Soviet industry fell by 20 per cent between

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[15] This was the average figure for the outcome of the second Five-Year Plan (1933-7), cited by Zaleski (1980), 232.

[16] Davies (1994), 145.

[17] Overy (1994), 199.

[18] Overy (1994), 346.

1939 and 1941. Output per worker was maintained only by the imposition of a longer working week with severe controls on timekeeping and absenteeism. Unfortunately, in the absence of prewar employment series for defence industry we cannot investigate the distribution of the Soviet shock between civilian and defence industry.

Nor, despite their tantalising coincidence of scale and timing, can we really be sure whether the underlying causes of the Soviet and German shocks were the same or different. The historiography of the German case appears to concur with Albert Speer in blaming Göring's regime ('incompetence, arrogance, and egotism', etc.). As for the Soviet case, the most likely cause was the overstraining of industrial and consumer supplies and labour motivation by the preceding wave of investment mobilisation, purges, now accelerating rearmament, and military operations in Poland, the Baltic, and against Finland on top. But in a broad and general sense the national context was the same in each case -- rapid rearmament, with an impatient government dominated by a sense of growing urgency, squeezing the civilian sector and throwing resources both material and financial at industry in order to get quick results, regardless of rising shortages and pressure on supplies.

In summary, German and Soviet industry both approached total war in 1940 with experience of rising military production, underpinned by several years of largescale investment in *Tiefrüstung* (armament in depth), mobilisation plans which were unrealistic and incomplete in hindsight (but how could these ever be otherwise), and a considerable reserve of poorly utilised capital and labour.

The production system

If Soviet wartime industrial achievements cannot be attributed to superior industrial resources, or nonindustrial resources, or a superior mobilisation capacity laid down before the war, then the production system must be considered as an independent factor. German failure and Soviet success in establishing mass production appear to have been decisive in determining comparative outcomes.

Documenting the comparative transitions is not easy. The accounts of the participants composed after the event speak eloquently in support of the mass-production hypothesis, but are self-interested. On the Soviet side, postwar planners and engineers were keen to claim wartime success in simultaneously cutting costs and achieving long runs of output of standardised weapons produced to the exacting standards required for interchangeability of parts, partly in a triumphalist spirit, partly because this was the lesson sanctified by high-level leaders to be marked and learned by postwar military-industrial managers at lower levels. On the German side the most vocal memoirists among the organisers of war production such as Albert Speer needed to emphasise the scale of the obstacles against which they had struggled, in order to promote their place in history.

German evidence from the time is more compelling, being less tainted with hindsight, and has been painstakingly assembled by Richard Overy. This evidence shows that German leaders concerned

with the overall balance of national resources were painfully aware of the excessive cost of maintaining a wide assortment of specialised weaponry continually redesigned to changing military requirements and finished according to the exacting craft traditions of German industry.[19]

Quantitative evidence which would enable a proper German-Soviet comparison is harder to come by. Wartime productivity series for Germany and the Soviet Union can be compared from tables 5.6 and 5.8. Table 5.8 shows that value added per hour worked in Soviet engineering and metalworking more than doubled during the war, and, with the increase in hours worked, value added per worker more than trebled. Table 5.6 showed that in Germany output per worker in war production more than doubled. In the German case, making up for the prewar loss of productivity explains part of the wartime gain, and the same factor may perhaps have been at work in the Soviet Union. Thus the scale of wartime productivity gains should not be surprising since it is clear that the scope for rationalising and cost-cutting in both countries was very great as the scale of war production rose. Value added per worker in Soviet industry increased by more than gross output per worker in German industry, but the share of value added in gross output probably rose in both countries.[20] The wartime gain was clearly faster and came sooner (most of it by 1942) in the Soviet Union than in Germany (not until 1944). These measures of productivity are certainly important, but they are not decisive since they tend only to confirm what we already knew.

Of more significance in illustrating different approaches to mass production is table 5.9, documented more fully in the case of Soviet aircraft in table 5.10. Table 5.9 shows that as late as the beginning of 1944 German industry was attempting to build several times the number of types of ground and air weaponry being built in the Soviet Union. While this sort of table is always vulnerable to international differences of definition, it seems likely that the variation revealed is too large to attribute to nuances of meaning.[21] Only after the reforms imposed upon industry and the army by Albert Speer in the early months of 1944 did the German assortment contract to Soviet dimensions or (in the case of aircraft) even less.

Table 5.10 illustrates the scale of mass production of Soviet aircraft, and also the underlying difficulties of evaluation. In the years 1941-5, 34 factories built 23 aircraft models. However, several models were built in more than one factory, and many of these factories built more than one model. The number of integrated production runs, therefore,

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[19] Overy (1994), 347-8, 352.

[20] Harrison (1996), 231-2..

[21] Overy (1995a), 201, remarks: ‘At one point in the war there were no fewer than 425 different aircraft models and variants in production. By the middle of the war the German army was equipped with 151 different makes of lorry, and 150 different motor-cycles’.

was neither 23 nor 34 but 70. More than 140 000 aircraft were built in total, on average roughly 6000 per model, 4000 per factory, and 2000 per run. Around these averages there was marked variation. Eight 'numbered' factories built three quarters of this total (an average of nearly 14 000 aircraft each), while 26 factories built the remainder (1250 each).[22] The longest single run was 15 000 Il-2 fighters at factory no. 18 -- more than one tenth of total Soviet wartime aircraft production by numbers. The eight largest runs accounted for three fifths of the total (11 000 aircraft per run). But the remaining 62 runs were on average of only 900 aircraft each. Thus there was certainly an impressive core of largescale mass production, but also a diffuse periphery of much smaller runs of a more variegated model assortment.

The character of demand and supply

In this differentiation of German from Soviet experience, both demand and supply factors were apparently at work. On the demand side we find soldiers of the different armies making different tradeoffs between quantity, quality, and variety. In Germany, the army and air force continued to insist upon a diversified assortment of weaponry specialised to different tasks and frequently adjusted to outward movements of the technological frontier, despite the ballooning cost in terms of national resources. Military inspectors and procurement agencies were unwilling to sacrifice qualitative improvement and assortment for the sake of long production runs and low cost; Hitler and Speer had to fight this tradition in order to impose fullscale mobilisation upon industry in 1943 and 1944.[23]

In contrast, in the interwar period Soviet munitions procurement agencies had evolved a rigid and coercive system for the enforcement of qualitative specifications and the rejection of substandard products, and also of standardisation and limitation of unit costs (see chapter 12). In the Soviet case the control of costs proved not to be the enemy of quality, so long as quality was interpreted as robustness and effectiveness in the hands of Soviet Army conscripts and the rough conditions of combat on the eastern front, rather than technological sophistication and finish for their own sake.

Thus it seems doubtful that Germany's relative lack of success should be ascribed to 'overbred organisation' (in Speer's words), or the 'ponderous inflexibility' of a 'heavily bureaucratic command economy'.[24] Both countries operated a bureaucratic system of military

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[22] In the same spirit Overy (1995), 186, notes that two thirds of all Soviet wartime tanks were built in three giant factories in western Siberia. But we do not know how the residual was distributed.

[23] Overy (1994); Abelshauser (1997).

[24] This is the view advanced by Overy (1995a), 206-7, who also supplies the citation from Speer.

procurement in which chiefs of staff were influential as consumers and were able to enforce their preferences. However, German and Soviet preferences differed. Soviet military chiefs were willing to trade off a certain degree of variety, specialisation to tasks, and frequent adjustment of weapons to the technological frontier for the sake of volume, uniform robustness, and low unit cost. The German military placed a higher value on variety, specialisation, and continual technological improvement, and continued to accept a sacrifice in volume, standardisation, and financial cost well into the war period. Thus the differentiating factor on the demand side lay in policy, not system.

As for the supply side, the enemy of mass production in both countries was the old-established artisan tradition of continental industrialisation. The leaders of Soviet industry had apparently been more successful in killing off the Russian prerevolutionary artisan tradition than their German counterparts who proved to be too heavily indebted to it to combat it when necessary. In the Russian case the suppression of craft resistance to mass production was certainly not achieved in a day. If we go back to the 1920s we can identify at least five historical phases of the process:

a) the destruction of rural handicrafts in 1929-30; compare prewar artisan employment in Germany and the Soviet Union (table 5.3 above).
b) the promotion of 'class-war' industrialisation during the first Five-Year Plan (1928-32), of which a key aspect was the revolt of young workers in largescale industry against craft traditions; simultaneously, a drive for mass production of standardised machinery products.[25]
c) the Stakhanov movement of 1935-6, including a renewed assault on restrictive craft traditions; simultaneously, a drive in defence industry for standardisation and interchangeability of parts in the teeth of perceived opposition from lingering artisan resistance.[26]
d) the purges of 1937-8.
e) the war itself, which finally entrenched the perceived virtues of mass production long into the postwar decades.

German experience was quite different. In prewar Germany the Nazi regime made a determined appeal to both industrial interests generally and the skilled worker in particular through comprehensive vocational training and apprenticeship programmes in industry. Superficially this course was driven by the needs of rearmament. Werner Abelshauser argues, however, that in practice it went far beyond such needs. At the beginning of the war traineeships represented something like 5 percent of the total workforce. This 'oversupply' of skilled workers persisted right through the labour shortages of the war period; towards the end of the war there were still

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[25] Cooper (1977); Kuromiya (1988).

[26] Siegelbaum (1988); see also chapter 4.

half a million apprentices in engineering. Indeed, Abelshauser picks out wartime investment in the human capital of the industrial workforce as one of the key factors in the German postwar economic recovery.[27]

It would be wrong to give the impression that the Soviet regime neglected vocational training either before or during World War II.[28] A quantitative comparison with Germany is not possible; however, it seems likely that Soviet policy was differently motivated and gave more restricted results compared with Germany's.

Conclusion

In this chapter I try to isolate the role of mass production in the production superiority of Soviet war industry compared with its German counterpart in World War II. In Germany the predilection of the armed forces for the latest novelty and the widest possible variety of weapons conspired with industry's artisan traditions to limit the scope for wartime rationalisation and cost reduction. In the Soviet Union, in contrast, both industry and the armed forces were committed to a mass production strategy, regardless of its disadvantages of restricted variety and the difficulty of interrupting production runs to upgrade weapons. This is not just the assertion of a stereotype but can be documented, although very imperfectly; more research, especially the development of better comparative quantitative indicators, would certainly be revealing. As a result, Soviet war production was able to accelerate faster when it was needed in 1942, and the Soviet Union outproduced Germany in overall volumes despite an industrial base inferior to Germany's in both scale and development level. However, it is not ruled out that the survival of a craft tradition paid off for Germany in its postwar economic recovery and development.

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[27] Abelshauser (1998).

[28] Harrison (1985), 139-40.

Table 5.1. German and Soviet war production, 1940-5 (physical units)

	1940	1941	1942	1943	1944	1945	Total
Germany:							
Ground and air munitions, thousands							
Rifles, carbines	1 352	1 359	1 370	2 275	2 856	665	9 877
Machine pistols	119	325	232	234	229	78	1 217
Machine guns	59	96	117	263	509	111	1 156
Guns	6	22	41	74	148	27	318
Mortars	4.4	4.2	9.8	23.0	33.2	2.8	77.4
Tanks and SPG	2.2	3.8	6.2	10.7	18.3	4.4	45.6
Combat aircraft	6.6	8.4	11.6	19.3	34.1	7.2	87.2
Warships, units							
Submarines	40	196	244	270	189	0	939
USSR:							
Ground and air munitions, thousands							
Rifles, carbines	1 462	2 421	4 049	3 438	2 451	703	14 524
Machine pistols	92	95	570	643	555	272	2 227
Machine guns	96	149	356	458	439	109	1 608
Guns	15	41	128	130	122	77	514
Mortars	38	42	230	69	7	3	390.1
Tanks and SPG	2.8	6.6	24.7	24.0	29.0	22.6	109.7
Combat aircraft	8.3	12.4	21.7	29.9	33.2	20.9	126.4
Warships, units							
Major naval vessels	33	62	19	13	23	11	161
USSR/Germany:							
Rifles, carbines	1.1	1.8	3.0	1.5	0.9	1.1	1.5
Machine pistols	0.8	0.3	2.5	2.7	2.4	3.5	1.8
Machine guns	1.6	1.5	3.0	1.7	0.9	1.0	1.4
Guns	2.4	1.8	3.2	1.8	0.8	2.9	1.6
Mortars	8.7	10.1	23.5	3.0	0.2	1.1	5.0
Tanks and SPG	1.3	1.7	4.0	2.2	1.6	5.1	2.4
Combat aircraft	1.3	1.5	1.9	1.5	1.0	2.9	1.4
Warships	0.8	0.3	0.1	0.0	0.1	..	0.2

Sources:
Ground and air munitions (SPG are self-propelled guns): Germany (within contemporary frontiers, so Greater Germany, but excluding occupied territories, in particular Czechoslovakia) is from IVMV, vol. 12 (1982), 200 (tanks in 1940 include armoured cars); USSR (also within contemporary frontiers) is from RTsKhIDNI, 71/25/7882, 4-20, except mortars from Harrison (1985), 250. Major naval vessels (excluding landing craft, torpedo boats, and other auxiliary craft) and submarines: Overy (1995b), 1060.

Table 5.2. Logistic curves fitted to war production series: five cases

	USSR		USA		United Kingdom				Germany	
$t = 0$	1944 (Q3)		1943 (Dec.)		1944 (Q1)		1918		1944 (July)	
k	1.0322	**	1.0763	**	1.0771	**	1.0657	**	569.09	
a	-3.6564	**	-2.3103	**	-2.5527	**	-2.8906	*	6.4055	
b	-1.3153	**	-1.7974	**	-1.0075	**	-1.5592	*	-0.34359	**
n	19		42		16		5		58	

Notes:
k, a, b, and t are parameters of the logistic curve of war production y, where:

$$y = \frac{k}{1 + e^{a+b \cdot t}}$$

Here t is time scaled in years set to zero at the measured peak of war production, k estimates the war production asymptote on which the logistic curve converges, a fixes the displacement of the curve's inflection point relative to $t = 0$, and b is a measure (with negative sign) of the rate at which saturation is progressively achieved. The number of observations is given by n.

* Significant at the 5 per cent level.

** Significant at the 1 per cent level.

Sources:
Soviet Union: Harrison (1996), 190 (output of ground and air munitions). Series are annual for 1940 (which counts four observations), then quarterly.

Britain, World War I: Hardach (1977), 87. Annual series, 1914-18, in physical units (rifles, guns, machine guns, tanks, aircraft) converted to index numbers and given equal weights in 1918.

Britain, World War II: Harrison (1990), 665; quarterly observations from the last quarter of 1939, with the first half of 1940 missing.

Germany: 1939 (Q4) to 1941: quarterly index numbers for armament and ammunition from USSBS (1945), 283, each quarter counting three observations; 1942 onwards: all munitions, monthly index numbers from Wagenführ (1954), 178-81.

USA: *Survey of current business*, February 1945, 24 (July 1940-December 1943), and table S-2 in subsequent issues. Thanks to Hugh Rockoff for this source. Series are half-yearly from July 1940 through 1941 (counting six observations each time), then monthly from 1942 onwards.

Table 5.3. Employment in the German and Soviet economies, 1939/40 (thousands)

	Germany, 1939	USSR, 1940
(A) The employed population		
Total	39 416	81 850
Agriculture	11 224	49 317
Nonagriculture	29 192	32 533
(B) Industry, construction, transport		
Total	18 638	20 064
Industry[a]	15 115	13 755
Large-scale industry	9 779	11 643
Artisan industry	5 336	2 112
Construction	1 399	2 355
Transport	2 124	3 954

Note:

[a] Including electricity supply, but excluding construction.

Sources:

Germany from Abelshauser (1998), table 4.17 (A); USSR from Harrison (1996), 258, 272. Figures for both countries include forced and foreign labour.

Table 5.4. The relative volume of industrial production in physical units, 1940 (Germany, per cent of USSR)

Iron ore	203
Pig iron	107
Crude steel	96
Electric power	77
Coal	61
Cement	52
Metal-cutting machine tools	47

Source: TsSU (1959), 60-1.

Table 5.5. Agricultural employment and productivity in Germany and the Soviet Union, 1938/40

	Germany, 1938/39	USSR, 1940
Agricultural workers, % of working population	26	57
Net output per worker in agriculture, % of nonagriculture	50	33

Source: Gatrell, Harrison (1993), table 8.

Table 5.6. Output per worker in German industry, 1940-4 (per cent of 1939)

	Basic industry	Munitions production	Consumer industry	Industry, total
1940	104.1	87.6	115.9	106.6
1941	114.6	75.9	133.3	104.2
1942	113.5	99.6	121.1	109.9
1943	108.7	131.6	124.7	115.5
1944	87.6	160.0 [a]	132.3	111.0

Note:

[a] Lower bound.

Source: Abelshauser (1998), table 4.14.

Table 5.7. Labour productivity in Soviet industry, 1928-50 (per cent of 1937)

	Industry value added	
	per worker	per hour worked
1928	100	94
1929	109	102
1930	110	107
1931	95	94
1932	71	71
1933	77	74
1934	84	80
1935	92	89
1936	101	99
1937	100	100
1938	101	101
1939	104	104
1940	102	91
1941	110	85
1942	143	100
1943	159	107
1944	156	106
1945	116	89
1946	84	69
1947	91	75
1948	103	85
1949	116	96
1950	113	100

Source:
Calculated as figures compiled for Harrison (1998b), appendix A.
Industry value added is measured at 1937 factor cost.

Table 5.8. Labour productivity in Soviet engineering and metalworking, 1941-5 (value added, per cent of 1940)

	Per worker	Per hour worked
1941	126	104
1942	247	182
1943	273	198
1944	290	213
1945	207	184

Source: calculated from Harrison (1996), 216.

Table 5.9. Numbers of weapon types in production in Germany and the Soviet Union, 1944

	Germany		USSR
	(A)	(B)	
Artillery	26	8	5
Antitank guns	12	1	2
Antiaircraft guns	10	2	3
Tanks, armoured vehicles	18	7	6
Aircraft	42	5	18

Sources:
For Germany see Overy (1994), 363; (A) is for January, and (B) shows post-Speer reform figures. For USSR, ground forces armament figures are derived from first quarter serial production data in RTsKhIDNI, except aircraft based on annual series in Kostyrchenko (1994), 235-7.

Table 5.10. Production runs of Soviet aircraft, 1941-5

(A) Totals and averages

Models	23
Factories	34
Runs	70
Aircraft	142 756
per model	6 207
per factory	4 199
per run	2 039

(B) By factory

Factory no.	Number of aircraft produced	Per cent of total aircraft produced
21	17 511	12
18	16 933	12
153	16 878	12
1	16 236	11
292	12 134	8
387	11 403	8
22	10 202	7
30	8 865	6
subtotal	110 162	77
Other factories	32 594	23
Total	142 756	100

(C) By model

Model	Factory no.	Period of production	Number of aircraft produced	Per cent of total aircraft numbers
Il-2	18	1941-5	15 099	11
Il-2	1	1941-5	11 929	8
Il-2	30	1941-5	8 865	6
U-2	387	1942-5	11 403	8
Iak-9	153	1941-5	11 237	8
Pe-2	22	1942-4	10 058	7
La-5, La-5fn	21	1942-5	9 229	6
Iak-1	292	1941-4	8 534	6
subtotal	..	..	86 354	60
Other aircraft	..	..	56 402	40
Total	..	..	142 756	100

Source: calculated from Kostyrchenko (1994), 235-7.