

**Arming the Reich:
Quantifying Armaments Production in the Third Reich 1933-1945**

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Adam Tooze

From the moment that Adolf Hitler took power in Germany on 30 January 1933, it was clear that armaments production was the central priority of his regime.¹ Within days of taking office Hitler made this clear both in confidential remarks to the cabinet committee on unemployment and in meetings with the military leadership. And the financial evidence is incontrovertible. Already in the first months of 1933, hundreds of millions of Reichsmarks were diverted towards the Reichswehr, an organization whose budget in the 1920s had rarely even reached a billion Reichsmark. By June 1933 the government agreed a spending package that was to provide no less than 35 billion Reichsmarks over 8 years for the military, raising military spending from less than 1 percent of GDP to between 4 and 5 %. And in practice, by the autumn of 1935 military spending was racing ahead of these targets, surging to more than 10 billion RM in 1936. In 1938 spending accelerated further to an extraordinary 20 percent of GDP.

Table 1 Military spending and utilization of German national product 1932-1938

Military spending accounted for 73 percent of the Reich's expenditure on goods and services as early as 1935. By the late 1930s perhaps as much as 50 percent of construction capacity was booked for use by the military.² As of the summer of 1938, more than 35 percent of crucial raw materials such as steel and copper were being diverted away from investment and export towards military needs.³ The Third Reich carried out what is probably the most dramatic and most rapid redistribution of national economic resources ever accomplished by a capitalist state in peacetime.

And the momentum continued after the outbreak of war. According to the best available comparative statistics, domestic resource mobilization by the Third Reich was greater in percentage terms than in any of the Western combatants at all times in the war.⁴ After 1943 it exceeded that even of Stalin's Soviet Union.

Table 2 Domestic Resource Mobilization for World War II

¹ For this and the following see the wider context offered by A. Tooze, *Wages of Destruction: The*
² F.W. Seidler, *Fritz Todt. Baumeister des Dritten Reiches* (Frankfurt, 1986), 212. See also Deutsche Bau und Bodenbank AG, *Die Entwicklung der deutschen Bauwirtschaft im Jahre 1938*, 6-13, which estimated that public construction accounted for 80 percent of all building activity in 1938
³ M. Geyer, „Ruestungsbeschleunigung und Inflation“ *MGM 30* (1981).
⁴ M. Harrison, 'Resource Mobilization for World War II', *Economic History Review* (1988), 184.

And yet, despite the obvious drama of this development, our knowledge of the quantitative dimension of armaments production in the Third Reich is remarkably sketchy. Acrimonious scholarly arguments have been carried on in a fog of empirical uncertainty. The literature on the 1930s relies largely on the budgetary figures of defence expenditure, but rarely cites figures for armaments production. The aircraft industry between 1933 and 1945 has been the subject of two excellent studies by Homze and Budrass.⁵ Both quote relevant data to show the dramatic expansion of the industry, but neither is quantitative in its primary focus. Similarly, Jost Duelffer's study covers the politics of naval construction between 1933 and 1939.⁶ However, his book too is devoid of all quantitative analysis. Knittel has contributed an important monograph on tank production, but this too provides little systematic quantitative information.⁷ There is thus a crucial missing link between the technical and political histories of rearmament and their wider economic context. A number of key arguments about the regime thus remain inconclusive and indeed for lack of evidence essentially undecidable.

I will focus here on four key points of contention.

In the 1980s Michael Geyer made the very interesting suggestion that the German rearmament processes in the 1930s should be seen as proceeding not along a smooth upward curve, but as a highly discontinuous process marked by accelerations (1933, 1935-6, 1938) alternating with serious setbacks (1934, 1937, 1939).⁸ This suggestion has gone largely ignored in the subsequent literature. The record of military spending clearly does suggest at least a lull in the armaments drive in 1937. And Homze and Budrass have both suggested that there was a serious setback to Luftwaffe production in that year. But how large in quantitative terms was this first armaments recession?

Secondly, the bitter dispute over the state of the Nazi economy in the late 1930s between Richard Overy and Tim Mason remains undecided, in large part for lack of systematic data.⁹ Mason famously argued that the Third Reich in 1938-1939 had been heading towards an economic crisis from which Hitler escaped by launching his country into war. Overy, by contrast, argued that the regime was fully in control of both the economic and

⁵ E.L. Homze, *Arming the Luftwaffe* (Lincoln Nebraska, 1976) and Budrass, L. *Flugzeugindustrie und Luftrüstung in Deutschland* (Duesseldorf, 1998).

⁶ Duelffer, J. *Weimar, Hitler und die Marine; Reichspolitik und Flottenbau, 1920-1939* (Duesseldorf, 1973).

⁷ H.H. Knittel, *Panzerfertigung im Zweiten Weltkrieg. Industrieproduktion fuer die deutsche Wehrmacht* (Herford, 1988)

⁸ M. Geyer, *Deutsche Rüstungspolitik 1860-1980* (Frankfurt, 1984)

⁹ T. Mason, *Nazism, Fascism and the Working Class* (Cambridge, 1995) and R. Overy, *War and Economy in the Third Reich* (Oxford, 1994).

political situation. In fact, Hitler and the military leadership were embarked on an enormous new phase of armaments expansion designed to equip the Wehrmacht for a major war in 1941-1942. The European war in September 1939 resulted not from a deliberate decision on Hitler's part, but from a disastrous diplomatic miscalculation. The debate between Overy and Mason was notoriously bitter. However, despite all the sound and fury neither protagonist produced any substantial data pertaining to the actual level of production in the late 1930s.

Thirdly, I will deal with the argument over German armaments strategy in the early years of the war. At least superficially, this is a quantitatively minded debate. The Blitzkrieg thesis first fully developed by Alan Milward in the 1960s was based on output data that appeared to show a remarkably slow mobilization of the war economy prior to 1942.¹⁰ This led Milward to claim that Nazi Germany was deliberately abstaining from total mobilization in the hope of fighting a series of short sharp campaigns, feeding each new war from the profits of the last. By contrast, Rolf Dieter Mueller and Richard Overy in their critiques of Milward focused primarily on productivity estimates, which appear to show a severe slump in productivity early in the war followed by a recovery after 1942 after the appointment of Albert Speer as Armaments Minister.¹¹ They argued, therefore, that Milward was the victim of a statistical illusion. The resources of the German war economy were fully mobilized for a total war after 1939, but this did not show up in a commensurate increase in output because of the chaotic inefficiency that prevailed at the top of the German state between the late 1930s and 1942. For both sides the winter of 1941-1942 was the crucial date - with the military crisis on the Eastern front and the appointment of Albert Speer as Armaments Minister. But whereas for advocates of the Blitzkrieg thesis, February 1942 marks the point at which mobilization began, for Overy and Mueller it is the moment at which Speer and his collaborators began a thorough going rationalization of the German war economy.

In this debate, therefore, both sides do present at least some data to make their case. On closer inspection however, the surprising fact is that both schools of thought rely on the same database, the compilation of industrial statistics provided by Rolf Wagenfuehr, Albert Speer's chief statistician.¹² First compiled during the war Wagenfuehr's industrial statistics

¹⁰ A.S. Milward, *The German Economy at War* (London, 1965) drawing on earlier work by B.H. Klein, *Germany's Economic Preparations for War* (Cambridge, Mass. 1959) and the United States Strategic Bombing Survey, *The Effects of Strategic Bombing on the German War Economy* (Washington, 1945).

¹¹ R. Overy, *War and Economy in the Third Reich* (Oxford, 1994) and R.D. Mueller in *Das Deutsche Reich und der zweite Weltkrieg (DRZW)* 5/1 (Stuttgart, 1988). The debate and its empirical foundations are subject to further analysis in J.A. Tooze 'No Room for Miracles' *Geschichte und Gesellschaft* (2005), 439-464.

¹² Published as R. Wagenfuehr, *Die deutsche Industrie im Kriege 1939-1945* (2nd edition Berlin, 1963).

and particularly his index of armaments production are an indispensable reference point for all economic histories of the German war effort. However, Wagenfuehr's index of armaments production provides detailed information only for the period after 1942 and is neither reliable nor sufficiently detailed in its coverage of the early war years, which is precisely the period actually in dispute. Clarifying the course of German armaments production in the period between 1939 and 1943, will therefore be the third major objective of this paper.

Table 3 Wagenfuehr's Armaments Index

It is evident both from the distribution of military spending between the three branches of the Wehrmacht between 1933 and 1939 and Wagenfuehr's wartime data that German armaments production fell into three unequal components: air, land and sea. For the war period Wagenfuehr provides detailed estimates of the share of each major kind of armaments production.

Table 4 Shares of Armaments Production

The huge importance of the air war for all combatants is one of the truly remarkable features of the industrial war effort in World War II. And it should be born in mind that the figures for "aircraft" include airframes and aeroengines, but not the very considerable expenditure of resources on anti-aircraft artillery, shells and bombs.

Alongside the modern air war, one noteworthy aspect of this data is the continued quantitative significance of ammunition. Shell factories, of course dominated the visual repertoire of World War I. By contrast they are largely absent from popular representations of World War II and almost completely absent from the historical literature on the conflict. And yet, the proliferation of automatic weapons, including rapid-firing weapons of larger caliber led to a dramatic escalation of ammunition demand particularly in the latter years of World War II. And there were advances in quality as well as quantity. Though World War I marked the essential breakthrough in indirect fire technology, allowing artillery to engage unseen enemies at long distance, one should not imagine that "traditional" arms such as the artillery underwent no further improvement after 1918. Due to improvements in explosives and powder, a 10.5 cm howitzer shell of 1917 vintage was not at all the same thing as its updated descendant of 1940.¹³ World War II shells packed a far more devastating punch than their predecessors in World War I. And though it is largely unacknowledged in popular and

¹³ For a proper appreciation see F. Hahn, *Waffen und Geheimwaffen des deutschen Heeres 1933-1945* (Bonn, 1998).

professional accounts of the Second War, the artillery in fact continued to be one of the dominant battlefield weapons even in the Blitzkrieg campaigns of 1939-1941.¹⁴

All in all, artillery shells clearly made up a far larger part of German armaments production throughout World War II than did tanks - twice as much at all times, three times as much in periods of peak production. The small percentage attributable to armoured vehicles in German armaments production even at the very end of the war, is a very striking feature of the data. And yet the evidence is inescapable and probably holds true for all the combatants with the possible exception of the Soviet Union, which avoided commitment to the strategic air war and was thus able to concentrate very heavily on its armoured forces.¹⁵

Unfortunately, the basis on which Wagenfuehr's produced his estimates of the relative importance of different sectors of the armaments economy remains obscure. However, Wagenfuehr's book does provide us with enough detail to allow us to unpick his monthly armaments index from the winter of 1941-1942 and to arrive at the underlying weighting scheme. We can do this by regressing the overall index of armaments output against its component series. This yields the following results.

Table 5 Wagenfuehr Index Unpicked

Regressing the Final Armaments Index on its components, yields the following:

<i>Regression Statistics</i>	
Multiple R	0.999399022
R Square	0.998798404
Adjusted R Square	0.964025605
Standard Error	2.295110803
Observations	37

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	0	#N/A	#N/A	#N/A
Weapons	0.12720911	0.023110222	5.5045	6E-06
Tanks	0.039238518	0.008080625	4.8559	4E-05
Vehicles	0.089777696	0.024228492	3.7055	0.0009
Aircraft	0.396000769	0.016821002	23.542	2E-20
Ship-building	0.102587425	0.011896081	8.6236	2E-09
Ammunition	0.219263917	0.023571279	9.3022	3E-10
Powder	0.048397396	0.034406145	1.4066	0.1702
Explosives	-0.00720704	0.017925607	-0.402	0.6906

¹⁴ For the role of artillery firepower in the crucial Sedan breakthrough in 1940 see Doughty, R.A. *The breaking point: Sedan and the fall of France, 1940* (Hamden Conn., 1990).

¹⁵ See the statistics in M. Harrison, *Accounting for war. Soviet production, employment and the defence burden, 1940-1945* (Cambridge, 1996)

The inability to assign a meaningful coefficient to the series for explosives is somewhat disconcerting, suggesting that Wagenfuehr was not entirely consistent in his application of the weighting scheme. However, the coefficients for the other series seem reasonable enough, especially since Wagenfuehr claimed that his index was based on the share of the different armaments sectors in total output in the latter half of 1943. Furthermore, Harrison in his reconstruction of the British armaments production index for World War II arrived at very similar coefficients.¹⁶

Table 6 The composition of British armaments output

With this weighting scheme as our guide we can set out to assemble the broadest possible array of sources on the production of the various categories of weapons for the period from 1933 until December 1941. When combined with Wagenfuehr's data for the period after the winter of 1941-1942, this will provide a full overview of armaments production in the Third Reich.

II

Aircraft are clearly the most important and thankfully the best-documented item on the agenda. Wagenfuehr supplies a monthly index of aircraft production from January 1942 onwards. A monthly series extending back to January 1941 is also available in the Appendix of the Summary Report of the United States Strategic Bombing Survey (Table 101).¹⁷ This fits the Wagenfuehr data well. And given the sophistication of the Air Ministry's statistical apparatus it is no surprise to find that this wartime data can easily be extended backwards using archival sources. In fact, data covering the delivery of aircraft are available on a monthly basis from the spring of 1933 onwards, up to December 1940.

The main problem in connection with the aircraft output data is to determine the appropriate weights by means of which to aggregate heterogeneous outputs of aircraft. Focussing simply on the number of aircraft produced is potentially misleading because of the enormous difference in complexity and cost between aircraft such as the lightweight Fiesler Storch courier aircraft and the Ju88 medium bombers, let alone heavy bombers such as the He 177, or even larger transport aircraft. The common solution in estimating aircraft production is to use airframe weights. And this was also the method apparently adopted by Wagenfuehr in his index. This certainly goes some way towards reflecting the difference in complexity.

¹⁶ M. Harrison, 'A Volume Index of the total munitions output of the UK, 1939-1944', *Economic History Review* 4 (1990), 657-666.

¹⁷ USSBS, *The Effects*, 276-7.

However, weighting by airframe weights harbours its own difficulties. Though it is true that complexity increases with size, it does not do so in proportion to weight. As the British found to their advantage as they concentrated ever more on heavy bombers, producing airframe tonnage in the form of large and heavy aircraft was considerably more efficient than mass-producing lighter aircraft.¹⁸

Prices are the obvious alternative either to aircraft numbers or airframe weights. However, this raises the unexpectedly controversial question of how the Luftwaffe's aircraft were priced. One of the myths that dog the history of the German war economy is the claim - perpetuated by incautious readers of Albert Speer - that prior to his appointment as Armaments Minister in February 1942, the Third Reich procured its armaments on a cost plus basis.¹⁹ If this had been true it would have provided an open invitation to inefficiency. Manufacturers would have maximized their profits by maximizing cost. And the replacement of such as system in February 1942 by a system of fixed and standard prices as proclaimed by Speer, would certainly go a long way towards explaining the supposed productivity miracle, with which Speer is sometimes credited. In fact, however, this story first coined by Speer and repeated by Alan Milward and those who followed him, is very misleading.²⁰ Germany's armaments bureaucrats were not naïve. As one would expect, they closely monitored the costing of key armaments producers. Cost plus contracts were used in some cases early in rearmament to incentivize new producers to take up unfamiliar and expensive new lines of production. But from the end of 1937 onwards the Air Ministry led the way in introducing fixed-price contracts. What they did not introduce, however, were standard prices. To enable production capacity to be expanded rapidly the prices offered to each plant were varied to reflect differences in cost structure. However, once the costs were assessed, prices were fixed and progressively squeezed downwards. In the brief and incomplete methodological appendix that accompanies the published version of his armaments index, Rolf Wagenfuehr claimed that the resulting discrepancies in price were so large as to defy simple summary. For this reason he opted to weight his aircraft index using airframe tonnage. It cannot be ruled out that by the later war years the Air Ministry was authorizing very large differences in the prices of aircraft delivered from different factories. However, an inspection of the procurement budget for the late 1930s suggests that at that point at least, the prices paid to different suppliers were

¹⁸ E. Devons, *Planning in Practice. Essays in aircraft planning in wartime* (Cambridge, 1950).

¹⁹ Boelcke, W.A. *Die Kosten von Hitlers Krieg. Kriegsfinanzierung und finanzielles Kriegserbe in Deutschland 1933-1948* (Paderborn, 1985), 44-46.

²⁰ As shown effectively by C. Rauh-Kuehne, "Hitlers Hehler? Unternehmerprofite und Zwangsarbeiterloehne" *HZ* 275 (2002), 1-55.

not sufficiently different to pose insurmountable obstacles to the use of prices as an alternative weighting scheme.²¹

The procedure adopted here is to present three indices for the period 1933-1940. One is simply the total of aircraft produced. The second is based on airframe weights derived from the USSBS figures for deliveries in 1941. The third is based on average prices paid for aircraft procured in the 1938 budget year, with the average for each aircraft weighted by the relative share of each factory in the total order.

Chart 1 German Aircraft Production 1933-1940

As the graph shows, too much has been made of the problem of index weighting. The correlation between the series weighted by airframe weights and by aircraft prices is 99.759. Weighting may matter more in the British case, where the composition of aircraft output shift dramatically over the course of the war – from defensive fighters to offensive heavy bombers. But in the German case the mix of light aircraft, fighters, medium and heavy bombers, in fact remained remarkably constant from the mid 1930s until the last year of the war. It was not until the spring of 1944 that the Luftwaffe finally concentrated the vast bulk of its manufacturing capacity on defensive fighters. There is, therefore, a very marginal difference between an index based on weights as opposed to one based on prices. This in turn means that there is no serious obstacle to following Wagenfuehr in his choice of a weighting scheme based on airframe weight.

The only remaining technical question is how to confirm that the archival series, which ends in December 1940, is properly “aligned” with the Wagenfuehr-USSBS series that extends back only to January 1941. A conventional splice, adjusting either the entire 1933-1940 series or the entire 1941-1945 segment by a certain fixed percentage is unsatisfactory given the lack of overlap and the need to assume consistency in composition of the two series. Instead, I have checked for the underlying consistency of the two series by comparing them both to a third set of data, which spans the break. To construct this comparison I have used the data for the monthly output of the main combat aircraft between September 1939 and April 1941, reproduced by Vajda and Dancey, apparently on the basis of an Air Ministry production plan of the spring of 1941.²² To ensure comparability with the more encompassing data before and after the break I have also allowed for the production of trainers, transports and other aircraft. For the comparable periods in each case the margin of disagreement in the number of aircraft recorded as having been produced is only 4.5 percent in the case of the Air Ministry

²¹ See for instance the budget papers for the late 1930s in BAMA RL 3 2477.

series and 2.1 percent for the USSBS series. When we construct a comparison on the basis of aircraft weights, the divergence is even less evident, see chart.

Chart 2 Matching the Air Ministry and USSBS Data

We can, therefore, assemble the following composite image of German aircraft production between 1933 and 1945, on the basis of airframe weights by simply abutting the data for December 1940 and January 1941 without making systematic adjustments.

Chart 3 Aircraft production 1933-1945: Airframe weight

III

Compared with the excellent data available on the Luftwaffe the situation regarding the Army is far more difficult. Prior to January 1939 it has proved impossible to find regular returns of armaments production for the Army either in published sources or in the archive. It was not until January 1939 that regular statistical summaries become available covering the delivery of important weapons and equipment. The best we can do for the earlier period is to infer monthly production rates from estimates for delivery rates produced in the course of bureaucratic arguments over raw materials rationing. The following table shows the erratic course of ammunition production in 1937, 1938 and 1939 as implied by these fragmentary sources.

Table 7: Estimates of German Ammunition Production 1937-1939

Only from December 1938 do we have a regular paper trail that allows us to produce a complete and continuous account of armaments production for the Army. Though this is regrettably late in the armaments drive it does at least allow us to cover the transition from peace to war. These data from archival sources for the period December 1938-December 1939 can then be linked with indices for weapons, ammunition and vehicle production compiled and published by the USSBS, which in turn can be spliced to Wagenfuehr's subseries over the winter of 1941-1942.

Following Wagenfuehr's lead I have weighted the production data for the period December 1938-December 1939, by unit prices for weapons, ammunition, tanks and motor vehicles. Adding these series yields a monthly figure for the value of military goods delivered to the German army. However, to ensure comparability with the later series, I instead combine the four series using the weights derived for the Wagenfuehr index. Not surprisingly there are differences in the levels and amplitude of movement in the two series, but not in their general direction of movement.

²² F.A. Vajda and P. Dancey, *German Aircraft Industry and Production* (Shrewsbury, 1998), 145

Chart 4: Armaments production for the Army 1938-1944

The results strikingly confirm the unsteadiness already seen in the Luftwaffe's production data. From a high point reached in early 1939 the armaments production of the German Army slumped badly in the spring of 1939, before entering a period of sustained recovery. The freakish figure for September 1939, is due to the bringing onto the books of hundreds of thousands of howitzer shells which had been left half-finished earlier in 1939 due to the lack of crucial raw materials, a point to which we will return below. Then in the first half of 1940 armaments production for the Army surged upwards, led by ammunition. This upward surge, however, was again interrupted in the summer of 1940 following the unexpectedly quick victory in France. There follows a lull in the latter half of 1940, which together with the similar lull in aircraft production has given rise to the debate about German armaments strategy. For Milward the plateau in armaments production indicated a decision by the regime to postpone total mobilization and to provide relief to the civilian sector. For Overy and Mueller, by contrast, it is a symptom of inefficiency. As we shall see to adjudicate between these two views of the armaments effort we must disaggregate Army armaments production into its main components.

IV

Compared to either army or airforce production, the distinguishing feature of naval production is its extreme lumpiness and its long lead times, features that do not lend themselves to statistical treatment. A single battleship of the Bismarck class cost in the order of 200 million Reichsmark - the equivalent of more than 2500 fighter aircraft. Each such ship weighed 40,000 tons and took almost 5 years to build. In total Hitler's Germany managed to build only two such vessels, flanked by a handful of somewhat smaller battle cruisers. Submarines were of course far smaller and far cheaper, but even a standard Mark VII U Boat, of which the Third Reich turned out just over 1,100, cost in the order of 2.5 million Reichsmark and took at least 10 months to produce.²³

On the other hand thanks to this lumpiness and thanks to the dedicated fact grubbing by the international community of naval buffs, the published documentation on German naval production is unparalleled in the detail it provides. We can trace the contract number and construction process for every single naval vessel brought into service. In practice, there are readily accessible published sources, which provide this information for all naval vessels

²³ These data come an excellent study of Blohm and Voss, Germany's largest private dockyard, which built both the Bismarck and large numbers of U Boats. See A. Meyhoff, *Blohm & Voss im "Dritten Reich"* (Hamburg, 2001)

ordered prior to September 1939 and for all U Boats for the entire period from 1933 to 1945.²⁴ Since U Boats came entirely to dominate construction in shipyards in Germany during the war and since we also have basic tonnage information on surface ships constructed during the war years, these sources provide the information necessary to construct a reliable measure of naval output.²⁵

Chart 5 Naval Production Unsmoothed

The question is how actually to measure dockyard production. The problems involved in simply counting tonnage launched or brought into service are well illustrated by the chart above. If we include capital ships, as we do in the data presented here, then for the period before 1939 there are wild fluctuations corresponding to the launching of individual big ships. The statisticians of the Kriegsmarine dealt with this problem for the war years by simply removing the capital ships from their data altogether. This produces the much smoother black line on the right hand side of Chart 5. But it also introduces a serious upward bias, since by excluding the capital ships whose production ceased in 1941 we are left with an aggregate that is entirely dominated by U-Boat output, which surged after September 1939. In effect we are ignoring the basic trade off, under which Germany's largest shipyards such as Blohm and Voss were only able to expand their production of standard VIIC U Boats by winding up the construction of capital ships.

To get round this problem I have resorted to the device of dividing the tonnage of each ship ordered by the Kriegsmarine over the entire period between the laying down of the keel and the month in which it entered service. By smoothing in this way we can properly account for "lumpy" capital ships, which were huge but which took many years to build, alongside the production of masses of U Boats, which were small but which were under construction only for a matter of months. The result, is an approximation at best since it does not allow for the varying intensity of the construction effort over the time between the laying down of the keel and commissioning. This, furthermore, is an extremely time consuming way of treating the data since it involves the case-by-case treatment of in excess of 1500 individual vessels. However, it certainly provides a far more complete and satisfactory indication of dockyard

²⁴ Pre-1939 orders are covered by the appendix contributed by Rohwer to Duelffer, J. *Weimar, Hitler und die Marine; Reichspolitik und Flottenbau, 1920-1939* (Duesseldorf, 1973). U-Boat orders for the whole period are itemized in E. Roessler, *Die deutschen U-boote und ihre Werften* (Koblenz, 1990). Thanks are due to Rose Sharke for assisting me in digitizing this data. A complete datafile is available from the author on request.

²⁵ G. Schulze-Wegener, *Die deutsche Kriegsmarine-Ruestung 1942-1945* (Hamburg, 1997). I am grateful to Dr Schulze-Wegener for clarifying a number of technical points connected to these tables.

output – perhaps one should rather say dockyard activity – than alternative measures based on launchings or commissioning that have previously been used in the literature.²⁶

Chart 6 Monthly Naval Construction Smoothed

V

Is it possible to assemble this motley collection of data on the three branches of the German armed forces into an overview of the development of German armaments production?

For the period before 1939 the evidence for the Army is very fragmentary, so we should concentrate on the Luftwaffe and navy production figures. Of these the Luftwaffe data is the most telling. Particularly striking is the pronounced slump in the Luftwaffe data as of the spring of 1937. As is evident in Chart 1, between March 1937 and the following winter all three indicators of Luftwaffe production showed a pronounced decline. Though growth resumed in early 1938, it was not until after the rapid acceleration in the course of the Munich crisis in the autumn of 1938, that monthly output consistently exceeded the peak level reached in early 1937. The Army data for the period up to early 1939 is fragmentary at best. But, as Table 7 shows, the evidence that is available hardly suggests a sharp acceleration of army armaments production between 1936 and early 1938. Naval production, certainly did continue to increase in 1937 as the pre-war capital ship building programme reached its height. However, from early 1938 onwards it too reached a plateau, from which it did not substantially increase until the declaration of war.

These findings are significant because they contradict the conventional periodization of the German armaments effort. It is commonplace in general histories of the Third Reich to treat the announcement of the Four Year Plan in September 1936, headed by Hermann Goering, as a major moment of acceleration in the armaments drive. Richard Overy has gone as far as to argue that it was only in 1936 that armaments actually began to dominate economic policy.²⁷ Nor is there any doubt that it was the intention of the German political leadership to accelerate armaments spending in 1937 and 1938, beyond the high level reached in the 1936 budget.²⁸ However, the production data suggest that no such acceleration actually

²⁶ A case could of course be made that similar smoothing techniques ought to be applied to all lumpy output, such as aircraft and big artillery pieces, which also took months to produce. However, though this is certainly a valid point, one has to bear in mind the differences in scale. Even in the early stages of the war, the monthly output of aircraft exceeded the total production of U Boats in the entire war. Even the largest aircraft cost only one tenth the price of a single medium-sized U Boat.

²⁷ The position taken both in R. Overy, *War and Economy* and R. Overy, *The Nazi Economic Recovery 1932-1938* (Cambridge, 1996).

²⁸ See the discussion in Tooze, *Wages*.

took place. It was not until tensions began to escalate over Czechoslovakia in May 1938 that the output of the Luftwaffe and possibly the Army as well began to dramatically accelerate. And, as we shall see, even this peacetime armaments boom proved to be short-lived.

We must strongly support, therefore, Michael Geyer's suggestion that 1937 constituted a serious setback to the Nazi rearmament drive. What accounts for this setback? Both Homze and Budrass have pointed to budgetary constraints as a major factor in restricting Luftwaffe expansion from early 1937.²⁹ And this was no doubt the immediate cause of programme cancellations and even a considerable downsizing in the aircraft workforce, the first since 1933. However, the more general backdrop to this decision to impose budgetary constraint was a severe macroeconomic imbalance, which expressed itself most forcefully in the acute shortage of foreign exchange. Since 1934 Hitler's armaments fuelled recovery had been sustained only through draconian regulation of imports and from 1935 onwards by means of a covert system of export subsidy, financed by a severe redistributive levy on German business. The Four Year Plan announced in September 1936 was intended to alleviate the problem, by halving Germany's import of raw materials and food. However, this was at best a medium-term solution. In the short-run the answer was found in the summer of 1936 in a draconian tightening of foreign exchange controls, a determined drive to requisition all foreign assets in private hands and the imposition in February 1937 of rationing for all key raw materials. Crucially, this gave the Ministry for Economic Affairs, at this point still independent of Goering's Four Year Plan, the power to redirect steel from domestic uses and towards exports.³⁰ And this prioritization applied to the Wehrmacht, as much as it did to the projects of the Four Year Plan and the rest of the German economy. Both the Luftwaffe and the Army found themselves by the summer of 1937 allocated rations that were entirely inadequate to maintain the pace of industrial expansion optimistically planned for in 1936. And it was the resulting political conflicts within the military that led to the conference between Hitler and the soldiers in November 1937 that is now known as the Hossbach conference. As in 1936, in response to economic difficulties, Hitler was forced to make a general statement of his strategic intent insisting on his intention to subordinate Czechoslovakia at the earliest possible opportunity. And from the data for the Luftwaffe it is clear that it was the foreign policy crisis over Czechoslovakia from the spring of 1938 that actually created the political conditions in which the regime was able to decisively shift resources away from civilian priorities towards armaments production, as it had apparently

²⁹ Homze, *Arming*, 153.

hoped to do 18 months earlier. As Michael Geyer showed years ago, it was in May-June 1938 that the decisive constraints – both with regard to money and raw materials - were finally lifted and the German armaments effort finally broke free from the plateau which it had reached in early 1937.³¹

Though the curve of dockyard activity does not follow that for Luftwaffe and army production closely, it in no way contradicts this more general story. By contrast with the immediate needs of the airforce and the army the raw material demands of the German navy were relatively modest. In the specialist literature the naval construction programme of the 1930s more than either the aircraft or army sector is described as capacity-constrained. Our new data on naval production clearly support this view. Under peacetime conditions Germany clearly lacked sufficient dockyard capacity and skilled labour to expand production much beyond the level reached by early 1938. Indeed, in the case of the navy the discrepancy between political rhetoric and industrial reality is even more remarkable than in the case of the Army and Luftwaffe. After 1937 as Hitler faced up to the necessity of a confrontation with Britain, the navy rose steadily up the hierarchy of the regime's priorities. This reached its climax in January 1939, when the Kriegsmarine's Z Plan was accorded the very highest priority in the entire armaments effort. However, despite this increased priority, the throughput of Germany's dockyards, at least as measured by our smoothed index of naval production, remained essentially static between the first months of 1938 and the outbreak of war. As was to become clear after September 1939 rapid increases in naval production were only possible by squeezing construction of other shipping. This was not done more determinedly before September 1939, presumably because of the vital importance of export contracts and of the general importance of shipping for Germany's export trade. In early 1939, in the wake of the Z Plan announcement, the military did take control over the allocation of all future shipbuilding work, civilian and military, with a view to enforcing the priority of naval production.³² However, there was not enough time before September 1939 for this to have any impact on the pattern of production.

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By contrast with the dockyards both the output of the Luftwaffe and the Army exhibited remarkable volatility from the summer of 1938 until early 1940, when both sectors began a dramatic ascent to wartime levels of production. Though the Army data prior to

³⁰ Tooze, *Wages*, 230-233 and the sources cited there.

³¹ Geyer, 'Ruestungsbeschleunigung'.

³² Meyhoff, *Blohm & Voss*, 234-43

December 1938 are approximate, it is safe to assume that both sectors saw considerable acceleration in the second half of 1938 and into the early months of 1939, as the peacetime armaments plans of the Wehrmacht reached their climax in the immediate aftermath of the Sudeten crisis. However, the really surprising finding for both sectors is that this upward trend in output was not sustained throughout 1939. As Hitler's escalated tension in Europe, first with the occupation of Prague and then by making threats against Poland, armaments output fell well short of the targets set six months earlier, see Table 7. Army output was hit from the spring. Luftwaffe's production began to slide from the early summer of 1939.

What is perhaps even more surprising is that this important evidence played no part in the bitter dispute between Richard Overy and Tim Mason over the situation of the German economy in 1939. There can be no doubt from the archive that the declining level of armaments production weighed heavily on the minds of German decision-makers. Faced with the cuts to the Army's production programmes General von Brauchitsch, CinC of the Army, spoke of the imminent extinction of the German Army's rearmament effort.³³ In the spring he went so far as to remind Hitler that in 1914 the German army had lacked one Army corps with which to push home its initial offensive against Paris. On the basis of the monthly production figures and projections he was receiving in the summer of 1939 he was mortally afraid that the German Army would again fall short. The Luftwaffe leadership was clearly very alarmed, forced as they were to cancel entire production runs of tried and tested aircraft, so as to be able to maintain the top priority project of the Ju88, which had been made the cornerstone of Luftwaffe expansion in the course of the Czech crisis. Furthermore, new archival material shows that Hitler was fully informed of the severity of the situation. Both in the spring of 1939 and again in the summer, Hitler's office demanded from the Army staff urgent information on likely future armaments output. Both requests were given the highest possible priority and were clearly outside the routine reporting procedures adopted since late 1938.

In searching for explanations for the remarkable setback to German armaments production in 1939, it is tempting, at least in the case of the Luftwaffe, to point to technical factors. The production cycle in the Luftwaffe was determined to an important extent by the development timetable. In 1939 a large part of the aircraft industry was being retooled for production of the new Ju88 medium-bomber, the aircraft, along with the Me 109 fighter, on which Goering had staked the future of the Luftwaffe. This conversion process necessarily

³³ BAMA RH 15/152 174-9. For an interpretation see Tooze, *Wages*, 285-325. For a view from inside the Army see B.R. Kroener, "Der starke Mann im Heimatkriegsgebiet". *Generaloberst Friedrich Fromm. Eine Biographie* (Paderborn, 2005), 317-322. The first little noticed reference to these files is to be found in

involved a hiatus in the production of other planes. However, this is not sufficient to explain the slump. Throughout 1939 the Luftwaffe staff were deliberately pruning back their programmes and they did this, like their counterparts in the army, under the irresistible pressure of raw material cuts. In early 1939, as in 1937, the Nazi leadership were struggling to maintain Germany's macroeconomic balance. The fundamental cause of the disequilibrium was clearly the fiscal imbalance, which by 1938 had become so severe that it was spilling over into serious monetary disruption. However, the most acute risk of crisis came from the balance of payments, where Germany in early 1939 faced a renewed risk of a severe foreign exchange squeeze. Already in November 1938 the absolute priority of the Wehrmacht, which had prevailed for the six months since May 1938, was overturned in favour of exports. On 30 January 1939 in his widely reported speech to the Reichstag Hitler had announced that Germany must "export or die". It was to secure the priority of exports that the allocations of steel and copper to the two most raw material intensive branches of the Wehrmacht were deliberately squeezed from the first months of 1939.

This balancing act was successful and Germany avoided a crisis of the kind that had almost toppled the regime in 1934. As Banken has recently pointed out, the ex-post foreign currency holdings of the Reichsbank were not actually deteriorating in 1939.³⁴ Like Overy he therefore concludes that economic factors cannot have been important in pushing Hitler towards war in 1939. Neither Banken nor Overy, however, appreciates the impact that this exercise in "fine-tuning" had on the German armaments economy. In light both of the statistics presented here and the expostulations by von Brauchitsch, there can be no doubt that the German armaments effort was suffering badly by the summer of 1939. And since Hitler was well informed about these problems, it seems unlikely, to say the least, that this did not influence his decision-making in August and September 1939. Certainly the data from the armaments factories, sheds new light on the comments reported by Speer, that Hitler in August 1939 believed himself to be facing a narrow window of opportunity in which Germany enjoyed a temporary military advantage over Britain and France.³⁵ In light of the dismal predictions for future armaments output, drafted for Hitler by the military in the summer of 1939, that window was closing fast.

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³⁴ R. Banken, "Die deutsche Goldreserven und Devisenpolitik 1933-1939", *JbW* 2003/1 49-78.

³⁵ A. Speer, *Inside the Third Reich* (London, 1970), 236. A point taken up by J. Duelffer, "Der Beginn des Krieges 1939: Hitler, die innere Krise und das Maechtesystem", *GG* 2 (1976), 443-470 and B-J. Wendt, "Durch das "strategische Fenster" in den Zweiten Weltkrieg", in W Backes, E Jesse and R. Zitelmann eds., *Die Schatten der Vergangenheit. Impulse zur Historisierung des Nationalsozialismus* (Berlin, 1990), 344-374

But, it is once war starts and the time series lengthen that our newly assembled production data really comes into its own.³⁶ On the basis of the Wagenfuehr weighting scheme and the data series for each branch of the armed forces presented above, we can extend Wagenfuehr's monthly index of armaments production back from the winter of 1941-1942 to the beginning of the war. The result is a new view of the first phase of the German war effort, the terrain so hotly contested between Milward, Overy and Mueller.

Chart 7 Monthly Armaments Production Index 1939-1941

What is most striking in the new monthly data is the very rapid acceleration in armaments production that took place in the first half of 1940. This boom in armaments production, which until recently has gone entirely unnoticed in the literature, was in fact the most sustained and most dramatic increase in armaments production in the entire history of the German war effort. In six months of uninterrupted growth, armaments output doubled. Our dockyard activity index shows a dramatic increase in naval output from the very outset of the war, which has previously been obscured by the reliance on delivery data, which show no increase until much later in 1940 and early 1941. The output of aircraft surged from early 1940, as the Ju88 production programme, finally got into full swing. The upsurge in Army output was dominated by ammunition production, which on Hitler's explicit instructions was given top priority in early 1940. Hitler's main worry seems to have been to avoid the kind of shell crisis that was widely thought to have crippled the Kaiser's armies in the autumn of 1914. The important implication of this finding, is that insofar as Hitler's armaments programme was geared towards an operational military design it was not the bold scything tank movement of the Manstein plan, the brains behind the Blitzkrieg. Nor could it have been. Manstein's extraordinarily risky scheme was not finally adopted by the German high command until February 1940, by which time the priorities of armaments planning had already been determined. Insofar as there was a battlefield plan underpinning Hitler's armaments strategy in the winter of 1939-1940 it appears to have been the original, far less imaginative army plan for the invasion of France, of November 1939. This called for a short, bludgeoning drive to the channel, followed by an aerial bombardment of Britain, an operation which promised no hope of immediately eliminating the French army and thus required backing up with a large-scale ammunition production programme. The chronology of military planning and the detailed statistics of German armaments production in the first nine months

³⁶ For detailed references for the following see Tooze, *Wages*.

of the war simply do not mesh with Milward's idea of the "Blitzkrieg synthesis". The scale of the armaments surge in the first half of 1940 is nevertheless remarkable.

Deciding how far this increase in output in the first phase of the war was due to increased resource mobilization or productivity increases, depends on data for inputs of labour and raw materials, which are currently available only on a fragmentary basis. One tentative comparison is suggested by the chart below which sets the monthly armaments production index against the best available data for workers registered as employed for the Wehrmacht between 1939 and the end of 1941.

Chart 8 labour and armaments production

This graph reiterates the point firmly established by Overy and Mueller that the German economy was mobilized with dramatic speed for war production. The surge in military employment was spectacular. However, whilst confirming this basic element of their interpretation the graph hardly provides ringing endorsement of their more general argument. It is possible to annualize this data so as to tell a story of continuously declining productivity between 1939 and 1940 and 1940 and 1941. However, this depends on placing great weight on the three data points for 1939, which are based on highly unreliable employment information. Indeed it cannot be stressed too strongly that all of the data on Wehrmacht employment for the early war years carry a severe health warning. As Tooze has shown in a recent article, the surge in Wehrmacht employment in 1939 and 1940 is almost certainly exaggerated.³⁷ Furthermore comparing twelve month averages for 1940 with a similar twelve month average for 1940 ignores the fact that Germany's industrial experience in 1940 fell into two halves: surging production and productivity in the first half of the year, followed by a relapse. According to the data assembled here, the ratio of output to employment reached by June 1940 was not exceeded again until July 1942. What we really need to explain are developments in the second half of 1940.

As is clear from Chart 7, following the stupendous victories over France, Belgium, the Netherlands, Denmark and Norway, the summer of 1940, perhaps not surprisingly, saw a break in the upward surge of armaments production. Over the following 18 months until the winter of 1941-1942, the armaments output of the Third Reich followed what can only be described as an unsteady course. And it is hardly an exaggeration to say that the entire literature on the war economy of the Third Reich revolves around the interpretation of this hiatus. On the one hand we have the view propounded by Milward of a deliberately restricted

³⁷ Tooze, 'No room'.

mobilization. On the other hand we have the inefficiency thesis of Overy and Mueller. Even a cursory examination of the disaggregated monthly production data suggests that neither interpretation is fully satisfactory. Contrary to Milward there is little evidence of any undermobilization of the German economy. But contrary to Overy and Mueller we must also query any generalized talk about “inefficiency”. Wagenfuehr’s highly pessimistic annual figures for aggregate armaments production on which Overy and Mueller’s productivity estimates are based are a seriously misleading guide to the development of the German war economy in 1940 and 1941. The truly distinctive feature of the Wagenfuehr index is the plateau in armaments production between the first and the second year of the war. However, as Chart 7 shows, on the basis of the monthly time series assembled here, it is simply not possible to reproduce this striking feature of Wagenfuehr’s data, certainly not using the weighting scheme that underpins his index number for the 1942-1944 period. Output did not stagnate between 1940 and 1941, it went up. Having said this however, it is immediately obvious when we inspect the disaggregated data that the more significant development of 1940 is in fact the divergent development of different elements of the German armaments economy. By contrast with the generalized talk of inefficiency and lack of strategic direction that is common to both Overy and Mueller, the disaggregated data suggest that in fact strategic intent left a clear imprint on German armaments production in this crucial phase of the war. Though we should discard his emphasis on the undermobilization, it is high time therefore to return to Milward’s insistent emphasis on the strategic intent guiding the German war effort. The German war economy after the defeat of France was not adrift. It was changing gear. This redirection may have been costly in the short-term, but it was clearly necessary for the effective management of the war effort as a whole.

It is the Army sector, in which this strategic intent is most obvious. As is clear from Chart 4, the pace of expansion in the Army’s output was not maintained beyond the summer of 1940. The overall output of the sector continued to rise, but at a slower pace and it was subject to considerable fluctuations. But what actually lies behind this break in the armaments curve is a spectacular divergence between the production of weapons, vehicles and tanks which continued to rise and the production of ammunition which dropped away precipitately in the second half of 1940. This striking discontinuity which is crucial in depressing the overall armaments index, clearly cannot be explained in terms of generic inefficiency affecting the entirety of the armaments economy, as suggested by Overy and Mueller. It was in fact the result of a deliberate decision to scale back ammunition production. In light of the kind of war that Germany now expected to fight a shift from ammunition to the production of tanks,

aircraft and naval vessels was clearly indicated. And the sharpness of this strategic turn is evident in the data. From the peak reached in the summer of 1940 ammunition output declined steeply. Growth did not resume until the early months of 1942. By contrast the production of tanks increased almost linearly from the outbreak of war in September 1939 until the end of 1942.

Chart 9 Ammo and Tanks

There can be no doubt of course that interrupting the upsurge in ammunition production in this abrupt fashion was not conducive to maximizing shop-floor efficiency. However, to have sustained the enormous rate of ammunition production in the summer of 1940, without regard to military necessity would have been entirely irrational.

From the summer of 1940 onwards, the record of German armaments production bears the hallmarks not of chronic inefficiency as Overy and Mueller argue, but of a deliberate balancing act. Returning to an earlier point, it was not over the winter of 1939-1940, but nine months later, in the autumn of 1940 that Hitler's can really be said to have adopted a Blitzkrieg strategy. The assumption of a swift decisive victory over the Red Army allowed the Third Reich to scale down ammunition production, releasing precious raw materials for other uses. But here too we must be careful in our interpretation of the "Blitzkrieg strategy". It is certainly true that as of the summer of 1940 Germany was no longer focussing all possible resources on maximizing current output of armaments, but this was not to the benefit of civilian consumption. Alongside the production of weapons, tanks and U Boats, what increased in 1940 and 1941 were exports – vital to sustaining the economies of Germany's allies and friendly neutrals – and investment, which surged spectacularly. Both were justified as contributions towards Germany's ability to sustain a long sea and air war against Britain and the United States. The Blitzkrieg strategy formulated in the summer and early autumn of 1940 was not intended to minimize the war's impact on the home front. It was intended to allow Hitler to prepare for two wars at once – the lightning campaign against the Soviet Union and the aerial war of attrition against Britain and the United States.³⁸

It is worth pursuing the story of Army production closely after 1940-1941 because it is this sector that, from February 1942, onwards was actually under the personal control of Albert Speer. It was not until the summer of 1943 that Speer's remit extended beyond the army to the navy. A close examination of the army production record is therefore essential if we are to get to the bottom of Speer's vaunted "armaments miracle". Speer had a sharp eye

³⁸ Tooze, *Wages*, 429-460.

for PR opportunities. And from the outset of his new administration he initiated a deliberate programme of armaments propaganda in close coordination with Goebbels. This gave top priority to big-ticket items such as tanks and locomotives – locomotives having been incorporated into his remit following the devastating crisis that hit the Reichsbahn during its first winter in Russia.³⁹ The propaganda circus surrounding tank production reached its crescendo in early 1943 with the so-called Adolf Hitler Panzer Programme, which initiated a stakhanovite production drive in the tank factories. Labour and raw materials were lavished on the key plants. Vehicles such as the Tiger and the Panther tanks were stylised into war winning miracle weapons, prefiguring the treatment later given to the famous V1 and V2 rockets. The mobile tank battles of the Eastern Front of course gave a dramatic substance to this propaganda rhetoric. Nor can it be denied that Speer was successful in raising tank production at a dramatic rate. However, what was true before February 1942 remained true thereafter. Tanks were a third rate factor in overall armaments production. In mid 1943 aircraft were seven times more important than tanks to overall production. The production of ammunition consumed at least four times as much resource. Within Speer’s personal field of responsibility it was the unheralded upsurge in ammunition production that was the driving force of the “armaments miracle”. More than half the entire increase in armaments production in 1942 was contributed by ammunition. Within Speer’s narrow sector of responsibility, ammunition remained dominant until the end of the war. And the evidence on productivity is even more striking.

Chart 10 Sectoral productivity levels

By breaking down the employment data provided by the Wehrmacht into sectoral sub series, chart 10 presents best guesses for sectoral productivity between early 1940 and the end of 1942. To illustrate the importance of ammunition, we have presented two series here covering Speer’s sphere of responsibility, one including ammunition, one without. The difference in the implied productivity trend when these two series are placed in relation to employment in “Army factories” is striking. As ammunition production surged in the first half of 1940, carrying overall army production along with it, so too did the productivity of those employed in army factories. The productivity curve for those in factories producing weapons, tanks and vehicles by contrast was relatively flat. And this pattern repeated itself in the spring of 1942 under Speer, where the surge in productivity within his sector was clearly accounted for in the first instance by the recovery in ammunition production.

³⁹ A.B. Gottwaldt, *Deutsche Kriegslokomotiven 1939-1945* (Stuttgart, 1973).

What then drove ammunition production? There is no space here for a full accounting of the ammunition sector, but labour and raw materials were clearly the two most crucial inputs. For labour we lack any continuous series at this disaggregated level. However, Kroener cites figures, which show employment in ammunition factories falling from 620,000 to 408,416 between the end of March and 1 August 1940, which suggests that having decided to cut back shell production, the Army was not idle in redeploying its workforce.⁴⁰ A more consistent series of data is available for raw material inputs. And these reveal a remarkably close correlation between the input of steel to ammunition production and the volume of ammunition produced.⁴¹

Chart 11 Ammunition and steel

This should really be the nail in the coffin of the simplistic story of productivity failure followed by rationalization peddled by Overy and Mueller. The dramatic upwards trend in overall armaments production was broken in the summer of 1940, at least as far as the army was concerned, by a deliberate decision to throttle back ammunition production by redistributing steel to other areas of the war effort. When Speer took office the main driver of the upsurge in production was the upsurge in ammunition production. And this in turn depended on Hitler's prior decision to endow the ammunition programme with a standing allocation of at least 300,000 tons of steel per month. It was on the back of this major redistribution of resources that ammunition production shot upwards, dragging the rest of the army armaments index with it. The fact that labour productivity increased in Speer's sector once sufficient steel was available to fully utilize the ammunition plants, merely confirms the point that raw materials were the rate-limiting factor.

For those seeking to sustain the thesis that the German war economy suffered from disastrous inefficiency in 1940-1941 the Luftwaffe is certainly the best source of evidence. And this is driven by two trends. On the one hand, after the victory in the West in 1940, labour was transferred very heavily towards Luftwaffe production. In 1941 it was the only armaments sector to significantly increase its workforce. Similarly the Luftwaffe producers benefited from an enormous investment programme in 1940-1941. On the other hand, production of aircraft remained at disappointing levels until the spring of 1942.

Unfortunately due to the destruction of records, during and after World War II, a full accounting for this strange hiatus in Luftwaffe output is still elusive. The series for the

⁴⁰ B. Kroener in *DRZW* 5/1, 788.

⁴¹ A good correlation, not shown here but available in the attached datasets, is also observed between steel allocation and weapons output.

Luftwaffe in Chart 10 is based on the figures for employment in “Luftwaffe factories” recorded by the statisticians in Wehrmacht high command. These show a dramatic fall in productivity in the latter half of 1940. So steep indeed is this fall that even by the end of 1942 the Luftwaffe does not appear to have recovered its previous levels of efficiency. This seems implausible, to say the least. It would seem to imply either that the employment data are inflated, or that the output series is not capturing some more dynamic components of production, for instance production of anti-aircraft weapons or bombs, which may have been included in the Luftwaffe sector on the employment side. Serious questions are certainly raised by the disconcertingly loose relationship between the Wehrmacht employment data and the more specific information collected by the Luftwaffe itself on employment in the airframe and aeroengine factories, shown in Table 8.

Table 8 Luftwaffe productivity.

These data do not contradict the general image conveyed by Chart 10. However, they do suggest a more reasonable trajectory for Luftwaffe productivity, which saw levels rising considerably after 1938, to a peak in the first half of 1940, before suffering a relapse, which was made good not until 1942. However, the very serious discrepancy both in the level and the trend of the employment data, should give one pause for thought about the likely margin of error in these estimates.

Nevertheless, if we take the figures in Table 8 at face value then there clearly was some deterioration in output per worker from the end of 1940. However, this was hardly disastrous and is perhaps best explained by reference to the general dislocation of the German economy caused by the strains of mounting the largest land operation in military history in the Soviet Union. Furthermore, as in the case of the navy we should consider the lead times involved in aircraft production. These mean that during a period of rapid workforce expansion such as 1941, it is not surprising to see a fall in productivity, as measured with reference to current output. Hundreds of thousands of new workers and literally dozens of new factories were incorporated into the Luftwaffe production programme in 1941. It is not surprising that the fruits of their labour were not visible until 1942 when aircraft output suddenly surged with no commensurate increase in labour input.

Furthermore, besides these technical rationalizations, Lutz Budrass has offered an important overarching corrective to Overy’s narrative of disorganization in 1940-1941. According to Budrass, the best explanation for the hiatus in Luftwaffe production around the battle of Britain, is not organizational inefficiency as implied by Richard Overy and Rolf

Dieter Mueller's interpretation of the German war effort, but technological uncertainty.⁴² In the aftermath of the Luftwaffe's first defeat, it was clear that top priority for the Reich's Air Ministry needed to be the introduction of an entirely new range of combat aircraft. The focus of the Ministry and the lead developers into 1941 was therefore on R&D and capacity expansion, rather than increasing immediate output. Meanwhile the enormous hinterland of sub-contractors, who serviced the key final assembly plants, had every incentive to diversify their product ranges, so as to hedge their risks in case of abrupt changes to the production programme. It was not until 1942 that the Air Ministry focussed deliberately on mass production. When it did so the results in terms of output were dramatic. In every respect the "armaments miracle" orchestrated by Erhard Milch in the Luftwaffe sector between the spring of 1941 and the spring of 1943, outdid that of Albert Speer. But this increase in output came, as everyone was aware, at the price of accelerated obsolescence.⁴³ The stepwise progress of aircraft production therefore reflects a sequence of highly complex technical decisions, followed by gigantic tooling up campaigns and huge reallocations of labour. It certainly cannot be reduced to a simple story of inefficiency in 1940 and 1941, followed by a new era of rationalization after February 1942.

Finally, as is clear from all of the data presented in this article, naval output followed its own trajectory, which defies rationalization in terms of either of the existing interpretations of the German war economy. The familiar story is that Hitler reluctantly abandoned the Z Plan, with its focus on battleships, at the beginning of the war and replaced it with a large-scale U Boat building programme.⁴⁴ This however produced few rewards, until the navy was briefly given top priority in the German armaments programme in the summer of 1940. Nor is it hard to see how one can support such a story with the widely used figures on naval deliveries, which see a major increase in U Boat production only from the very end of 1940. Between the early summer of 1940 and the end of 1941 the delivery data increase by a factor of nine! The smoothed series preferred here tell a far more plausible story about the conversion of the German dockyards to naval production. From the moment at which Hitler abandoned the Z Plan in favour of U Boats, surface ship construction declined, but this was more than made up for by the swift development of U Boat construction. Though the new orders of the autumn of 1939, could not immediately manifest themselves in newly commissioned vessels, keels were being laid down over the winter of 1939-1940 and the pace

⁴² Budrass, *Flugzeugindustrie*, 600-636.

⁴³ Budrass, *Flugzeugindustrie*, 705-766.

of construction accelerated steadily, to reach the target of roughly 20-25 new Boats per month by early 1941. The capacity constraint of the prewar period was decisively broken, through the wholesale conversion of the dockyards from civilian to naval production and within the naval programme from big ships to U Boats. In fact it seems that the wartime expansion of German naval production, focussed as it was on U Boats, was accommodated largely within the envelope of prewar capacity. Certainly this is true at the aggregate level and it is an interpretation confirmed by the experience of Germany's largest shipyard, Blohm and Voss. Overall dockyard output did not go up. But the share going to the Kriegsmarine was hugely increased. This was enough to sustain a very rapid increase in naval output until the summer of 1941, after which there was a more modest increase in 1942.

The primary driver of naval output was clearly the mobilization of civilian capacity. However, to counterpose mobilization to rationalization as though they were mutually exclusive modes for increasing output, is clearly misplaced. The increase in naval output enabled the dockyards to benefit from economies of scale and learning efficiencies that were impossible to achieve under peacetime conditions. This was most evident in relation to production of the standard medium U Boats, of Mark VII type, of which the German dockyards produced more than 1100 by the end of the war. According to data compiled by Germany's leading U Boat historian, the cost saving on Mark VII U Boats delivered in early 1942, as opposed to late 1940, were in the order of 25-30 percent. And the most rapid period of learning, unsurprisingly, was in the early period of the war, rather than after 1942. As can be seen in Chart 10, these figures from individual dockyards agree nicely with the steady upward productivity trend derived for the naval sector as a whole from the smoothed output data and Wehrmacht employment figures.

Defeat, as far as the German navy was concerned, came rather sooner than for the rest of the Wehrmacht. In May 1943, U Boat losses in the battle of the Atlantic rose to unsustainable levels and though the Germans were periodically able to sink serious amounts of Allied shipping they had lost the battle of the dockyards. Doenitz therefore took the decision to withdraw the U Boats from the main Allied shipping lanes. Following this defeat, Speer took over political responsibility for naval production.⁴⁵ But rather than abandoning the naval war and running down the industry in favour of the production of more promising weapons, he engaged in a major reorganization of the industry in the hope of accelerating

⁴⁴ With a characteristic emphasis on disorganization see, G. Thomas, *Geschichte der deutschen Wehr- und Ruestungswirtschaft* (Boppard, 1966).

⁴⁵ For the following see Tooze, *Wages*, 611-618.

mass production of the revolutionary new Mark XXI U Boat. At the time and since Speer's new sectional construction system, modelled on the fabled Kaiser yards of the US, was hailed as one of the great triumphs of the German war effort. However, as recent research has revealed, though the throughput of some of Germany's dockyards may have increased, Speer's new system was riddled with problems of quality control. And due to a mass of unforeseen problems both with the design and manufacture of the new U Boat, only two Mark XXI U Boats ever set to sea in anger, within days of the end of the war. In our consideration of the German war effort, it seems safe therefore to discount this late "triumph" of productive ingenuity and to end our discussion in the spring of 1943.

VII

In summary, the consistent theme running through this article is a critique of voluntarism. There was less "slack" in the German armaments economy than is commonly supposed. There was less generalized "inefficiency" and consequently also less scope for reference to generalized political factors, such as the supposed polycratic inefficiency of Hitler's regime. The pattern of output was determined in the short-run largely by inputs of labour and raw materials. There were of course opportunities for dynamic economies of scale. But these could not be unlocked at the flick of a political switch, or by acts of inspired leadership as the propaganda of the Speer Ministry would have one believe. Achieving economies of scale and learning depended on the accumulation of resources and experience. Where political influences entered the story was in the allocation of labour and raw materials. And the detailed figures of armaments production presented here, many of them for the first time, suggest that this allocative power was exercised with a good deal of determination by the Nazi regime and indeed by Hitler himself. Under peacetime conditions, the Nazi leadership did not hesitate to reign in armaments production in the interests of macroeconomic balance. After September 1939 the regime orchestrated a very determined mobilization of both labour and raw materials, with visible productive results. And when military events took a spectacularly unexpected turn in May-June 1940, the regime responded with a swift change in direction, a feat repeated again over the winter of 1941-1942 after the debacle at Moscow. These findings in short should lead us to reassess not only our understanding of the economic history of the Third Reich, but of the political history of the regime more generally, especially since their qualified "intentionalism" is in tune with recent research on other crucial areas, such as racial policy and the Holocaust.

More generally, however, though this article hopes to have moved the debate forward, it is clearly very far from being a complete accounting of German armaments production in

the Third Reich. For that we need much more systematic and reliable information on inputs to combine with the data presented here on armaments output. This is some way off. Indeed, given the deficiencies in the archival sources, it may not be fully attainable at the aggregative level. We may be better advised to explore microeconomic perspectives. However, in the mean time it is hoped that this survey makes at least one point clear. Much basic work remains to be done in the economic history of the Third Reich. For too long the literature has been content to rely on data which is not adequate to answering the kinds of questions that we want to ask.