

British Tank Production and the War Economy, 1934–1945: Important Considerations for Industry[†]

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Abstract

This article illustrates that the production of tanks by British industry during the Second World War provides important considerations for peacetime industry to produce heavy and complex machines on a commercially successful and sustainable basis. Notably, delays and shortages in material components must be minimized to avoid interrupting the rate of output. Spare parts have to be available in sufficient quantities to ensure continued performance once the equipment has left the factory and similarly the inspection regime on the assembly line has to be adequate to maintain the highest level of build quality. The continued production of older equipment may be necessary to avoid inactive workers and every effort should be made to ensure that the production process benefits from as much standardization, specialization and simplification as possible. Finally, there are significant risks of becoming too reliant upon production from overseas sources. This article discusses these considerations with case examples from the wartime period by using untapped information held within the archives of industry alongside the more traditional sources available in national repositories. Overall this analysis shows that the British process of manufacturing tanks under wartime conditions was not that different from the experiences of other Western Allies.

Introduction

The involvement of British industry in the production of tanks during the Second World War has been ignored by historians. There is a sizeable amount of evidence available within the archives of industry to highlight the experience of the different firms involved in the design and production of these very complex and heavy pieces of military equipment. To illustrate the importance of why the tank industry during this conflict should be examined is shown in Table 1 for the comparative output between Great Britain, Germany and the United States. It is clear from the sizable number of tanks delivered by each combatant that production would have required a great deal of centralized organization, industrial planning, labour and material resources.

[†] A version of this paper was given to members of the Research Institute for the History of Global Arms Transfer, Meiji University, Tokyo, 8 March 2017. Coombs, *British Tank Production*.

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Table 1. *Tank output in Britain, Germany and the United States, 1940 to 1945*

Year	Britain	Germany	USA
1940	1,379	1,139	331
1941	4,837	2,373	4,052
1942	8,622	2,159	24,997
1943	7,217	7,552	29,497
1944	4,000	7,903	17,565
1945	964	924	11,968
Total	27,019	22,050	88,410

Sources: TNA, AVIA 46/188, ‘Monthly Deliveries of Infantry and Cruiser Tanks by Firms, 1939–1943’, draft official history narrative by D. Hay, after 1950, pp. 269–71; CAB 120/355, ‘A.F.V. Production’, 1943; CAB 120/356, ‘A.F.V. Production’, 1944–5; Thomson and Mayo, *United States Army*, p. 263; Ness, *Jane’s World War II Tanks*, pp. 86–8 & 187.

It has been well established that British tanks during much of the war were troubled by issues of being unreliable or having inadequate firepower and being unsuitable for ‘Blitzkrieg’ style warfare. Many of these published arguments have come from a generally negative attitude towards the British experience in producing tanks and based upon limited research carried out in The National Archives in Kew and the Tank Museum in Bovington.¹

Academics have provided a more positive account of the British tank programme by identifying that British tank designs became more reliable and effective later in the war.² There is still the need however to highlight how this was achieved from an industrial perspective within the context of political and strategic pressures together and international comparisons.

The issues of tank design since their inception just over 100 years ago to modern day have needed to find the required balance between the three key areas of firepower, armour protection and mobility. First, the level of firepower from the main gun is limited by the size of the tank. Second, the size of the tank affects the amount of armour protection as this will impact upon the maximum weight of the tank. Third, the weight of the tank determines the mobility and speed of the tank from the most powerful engine available at the time.

Essentially, British industry had to overcome the issues of design, development and production to meet the objectives of the military which adapted to the changing strategic situation to demand greater mobility for fast moving offensive action overseas. The experience of British industry during the war has identified a number of key considerations which arguably remain just as important during peacetime when dealing with the production of complicated machines on a mass produced basis. These considerations can be illustrated by a number of examples drawn from the experience of the British tank firms for each case, together with important comparisons from the industries of the United States and Canada.

¹ Fletcher, *Great Tank Scandal*; Fletcher, *Universal Tank*; Beale, *Death by Design*.

² Buckley, *British Armour*; Peden, *Arms*.

I

The first such consideration is how the ability of industry to commence production and then maintain the required rate of output will be affected by delays and shortages in the supply of labour and material components used on the assembly line.

By means of an example, during September 1939 commercial vehicle firm Leyland Motors received an order to produce 151 new Covenanter tanks which was later increased in June 1940 to 251 tanks. The schedule for this order expected the first tank to be completed in July 1940 and final tank would be delivered 12 months later during July 1941.³ The Covenanter was not a successful tank and despite a total of 1,770 rolling off the assembly line, they were deemed unbattleworthy and not sent to the front line.⁴ For Leyland Motors, the combination of delays in the construction of the new factory, problems with the supply of labour and components such as armour plate, and the effects of German bombing meant that delivery of the first tank was five months late in December 1940. The continuing irregular interruptions in the supply of assembly components meant that tank number 251 was not delivered until February 1942 and now seven months after the July 1941 due date.⁵

By comparison, early tank production by the Montreal Locomotive Works in Canada was delayed for two months from June to August 1941 due shortages in the supply of transmissions.⁶ The start of Valentine production by the Canadian Pacific Railway Company was similarly delayed by three months from February to May 1941 due to shortages in components, labour and time consuming production techniques with hand tools and paint brushes.⁷ As a result of these on-going assembly delays the total number of completed Valentine tanks in Canada was limited to just 30 from an expected 105 tanks between May and September 1941.⁸

One way in which the problems of labour supply were overcome was by the transfer of workers from one firm to another. This occurred during a slowdown in production when older tanks were being phased out to make way for the latest design. As shown in Figure 1 this was demonstrated to good effect from December 1942 when Ruston & Hornsby transferred workers at the end of their Matilda production to help increase the production of Crusader tanks at Ruston–Bucyrus. The loaned workers were returned to Ruston & Hornsby in February 1943 to start production on the new Cavalier tank.⁹

³ British Commercial Vehicle Museum (hereafter BCVM), Leyland Motors, M639 143/11, General Manager's Meetings, 1938–40 'Summary Report', September 1939 to June 1940.

⁴ TNA, AVIA 46/188, 'Monthly Deliveries', pp. 266–71; CAB 120/355, 'A.F.V. Production', 1943.

⁵ TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269–70; BCVM, M639 143/11, 'Production Issues', August 1940; Leyland Motors, M632 143/5, 'Mark V', January 1941.

⁶ Churchill College Archives, First Viscount Weir, WEIR 20/9, Report on visit to Montreal Locomotive Works by Hoare, 21 April 1941.

⁷ Library and Archives Canada (hereafter LAC), vol. 2596, HQS-3352–4, tank meeting in Washington, 20 September 1940; HQS-3352–3, vol. 1, Eighth meeting of the Joint Committee, 18 February 1941; Eleventh meeting of the Joint Committee, 1 May 1941; Fourteenth meeting of the Joint Committee, 29 May 1941.

⁸ LAC, HQS-3352–3, vol. 1, Ministry of Munitions and Supply to Master-General of the Ordnance, 4 February 1941; Historical Section, 'Tank Production in Canada', pp. 3–5.

⁹ Heritage Motor Centre (hereafter HMC), Sir Miles Thomas, 80/20/1/7 & 8/7, Ruston-Bucyrus to Ministry of Supply, 1 March 1943; TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

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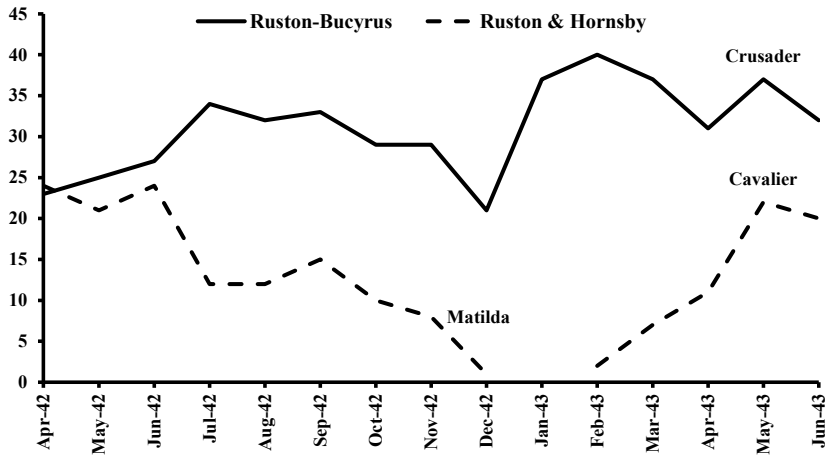


Figure 1. Tank output by Ruston-Bucyrus and Ruston & Hornsby, April 1942 to June 1943.

Source: TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

The problems of shortages of assembly components were overcome by the improved tank designs and production techniques of the later models. As shown in Figure 2 this was demonstrated by the transfer of production at Leyland Motors from the Centaur tank at the end of 1943 to the new Cromwell tank and then later to the Comet tank at the end of 1944 and into 1945. With each transfer Leyland Motors was able to expand production at a faster and greater rate of output over a shorter period of time despite experiencing similar delays

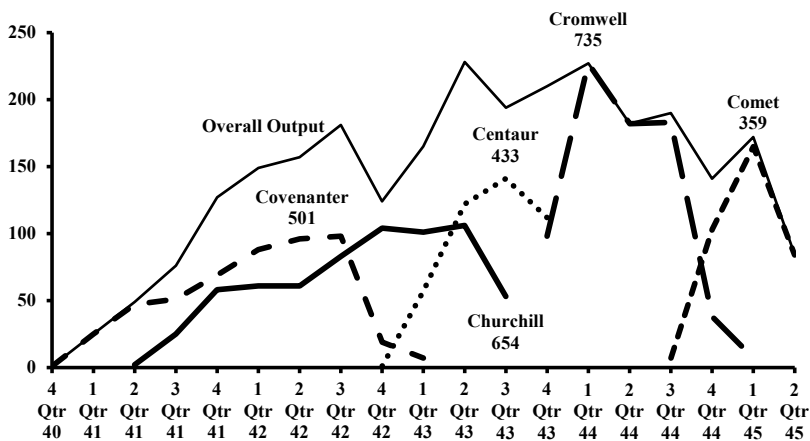


Figure 2. Tank output by Leyland Motors, December 1940 to May 1945

Sources: TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269–71; BCVM, M632 143/5, General Manager's Meetings, 1941–3; M631 143/5, General Manager's Meetings, 1944–5.

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in material shortages.¹⁰ The advantages for front line units were two-fold. Firstly, when compared to the output of the Covenanter and Centaur tanks, both the Cromwell and Comet tanks were immediately battleworthy. Secondly, the sustainably high rate of output achieved with these later tanks meant that battlefield losses could be replaced quickly. These benefits will be examined in more detail later with the sixth consideration of industry.

II

The second consideration is that industry must supply enough spare parts to support the deliveries of finished products or risk having the customer being unable to use the equipment in event of mechanical breakdown.

For Britain the demand for greater tank output during the first half of the war meant that the production of spare parts was directed to completing the final assembly in the factories instead of being received by tank units in training at home or front line action overseas.¹¹ The affect of this policy was illustrated during the battles in North Africa during 1941 when more spare parts than that supplied were needed to repair damaged tanks in the field so that they could be returned to operational status.¹²

By comparison the aircraft industry during the Battle of Britain reduced spare parts production in order to concentrate upon delivering more fighters to the front line squadrons.¹³ Similar to the British tank industry, the performance of American tanks used by British units in North Africa during 1942, such as the Grant Tank, was also affected by shortages in the supply of spare parts coming from the United States.¹⁴

To illustrate the British situation in more detail, during July 1941 the number of British tanks in workshops or with the units that were considered “unfit for action” was 26 per cent with the lack of spare parts being a major reason.¹⁵ The proportion of “unfit” tanks had deteriorated to 28 per cent by September 1941 before falling to 18 per cent by November 1942.¹⁶ However it should be noted that the number of “unfit” tanks deemed acceptable by Prime Minister Winston Churchill back in July 1941 was limited to just 10 per cent.¹⁷

The tank authority under the Armoured Fighting Vehicle Liaison Committee in October 1942 reacted to improve the situation for front line units with the decision to ensure that industry supplied tank spares at the same time as new tank output.¹⁸ However this took time to achieve with tank firm Mechanization & Aero recording the production of spares in 1942 at 22 per cent of total output which also excluded tanks, engines and gearboxes. This balance had improved to 37 per cent in 1943 and increased to 45 per cent in 1944.¹⁹

¹⁰ BCVM, Leyland Motors, M631 143/5, ‘Ministry of Supply Contracts’, Cromwell material shortages: January to April, June, August, November and December 1944; Comet material shortages: September and October 1944 and April 1945.

¹¹ TNA, CAB 98/20, Second meeting of the Tank Parliament, 13 May 1941.

¹² TNA, WO 185/8, Eighteenth meeting of the Tank Board, 11 July 1941.

¹³ Ritchie, ‘New Audit of War’, pp. 128–9.

¹⁴ Nuffield College Library (hereafter NCL), Lord Cherwell, CSAC 80.4.81/G.367/19–22, Harriman to Under Secretary of War, R. P. Patterson, 13 July 1942.

¹⁵ TNA, PREM 3/426/16, ‘Tank Return for the United Kingdom’, 27 June 1941.

¹⁶ TNA, PREM 3/426/16, ‘Tank Return for the United Kingdom’, 21 September 1941; CAB 120/355, ‘State of Readiness of Operational Tanks’, 17 September and 26 November 1942.

¹⁷ TNA, PREM 3/426/4, Churchill to Margesson and Beaverbrook, 11 July 1941; CAB 120/355, ‘Summary of Tank State of Readiness’, 25 March 1943.

¹⁸ TNA, WO 185/7, Second meeting of the A.F.V. Liaison Committee, 27 October 1942.

¹⁹ Modern Records Centre, Mechanization & Aero, MSS.226/NM/2/1/5–10, ‘Trading Account’, 1939–44.

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The standardization of tank components eventually improved with those firms delivering the Cromwell tank from December 1942 and the Comet tank from September 1944, especially as these tanks both used of the Meteor tank engine. The Meteor was a 600 hp engine which had been converted for tank use from the original Merlin aero-engine used in the Spitfire.²⁰ The Meteor provided British tanks with greater reliability, increased armour protection and simplicity in the provision of spare parts. This situation was a vast improvement on the 340 to 385 hp Liberty tank engines used in Crusader tank until production ceased in October 1943 and in the Cavalier and Centaur tanks until production of these unbattleworthy tanks both ended in April 1944.²¹

III

The third consideration is that industry must ensure that enough quality control inspectors are employed to identify problems on the assembly line and react to increases in output or risk delivering faulty equipment to customers.

Within the British tank industry the method of official inspection adopted by the Ministry of Supply could only carry out a final inspection of the tank once fully assembled. This practice continued until at least 1944 and meant that faults on the production line were overlooked.²² By comparison, the aircraft industry in Britain carried out an inspection of the work in progress at each stage of production prior to the final assembly.²³ Similar to the situation found in the British tank industry, the mechanical problems found with American tanks received by British units in North Africa were caused by assembling the tanks too quickly and having an inadequate inspection programme in the factories.²⁴

In addition to only reviewing the fully assembled tank, the problems with the official system of inspection within the British tank industry were due to a shortage of inspectors available to carry out the necessary checks. The situation deteriorated even further when the demand for greater tank output from 1940 to 1942 meant that there were more tanks leaving the assembly line than could be properly inspected at completion. As shown in Figure 3 although more official inspectors were employed after June 1942, the proportion of inspectors at the Tank Department fell from 75 per cent of the total number employed in December 1940 to 58 per cent in June 1943. This was caused by the increased emphasis on increasing the tank design section which doubled from 13 per cent to 26 per cent over the same period.²⁵

²⁰ TNA, WO 185/8, Ninth meeting of the Tank Board (Reconstituted), 8 January 1942; BCVM, M631 143/5, 'Comet Production', September 1944.

²¹ TNA, CAB 102/851, 'Brief Particulars of British, American, Russian and German Tanks', October 1944; CAB 120/355, 'A.F.V. Production', 1943; CAB 120/356, 'A.F.V. Production', 1944–5.

²² HMC, 80/20/1/7 & 8/15, Thomas to Director-General of Armoured Fighting Vehicles, C. Gibb, 10 March 1944.

²³ Ritchie, 'New Audit of War', p. 135.

²⁴ NCL, CSAC 80.4.81/G.368/5, Special Supplement, 'Grant and Sherman', 6 February 1943; CSAC 80.4.81/G.368/8, Special Supplement, 'American Tanks: Defects on Arrival', 2 February 1943; CSAC 80.4.81/G.368/9–10, Special Supplement, Technician to GMC, 20 January 1943.

²⁵ TNA, AVIA 46/188, 'Numerical Strength of Tank Department', p. 114.

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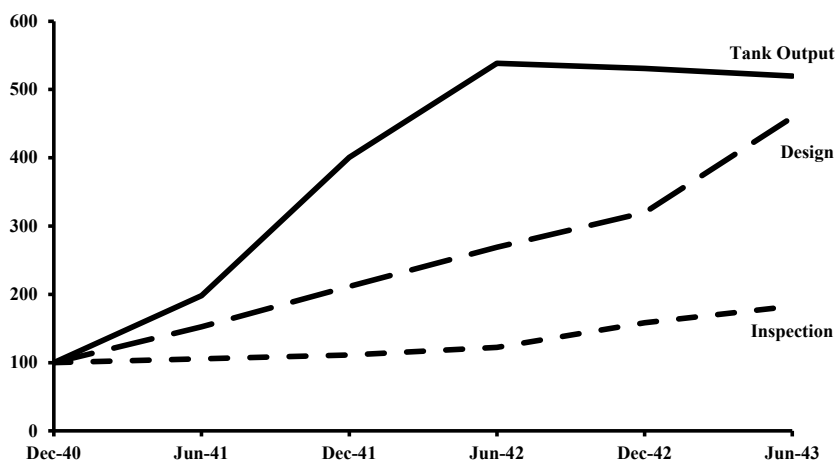


Figure 3. *Index of the number of Tank Department design and inspection employees compared to the expansion of tank output from December 1940 to June 1943*

Sources: TNA, CAB 120/356, 'A.F.V Production' January to December 1944; BT 87/137, 'Assignments from U.S. War Department', by P. J. Grigg, 15 December 1944.

The system of tank factory controlled inspection was also inadequate for too long. Parent firms were responsible for the co-ordination of inspection carried by the tank firms in the production group, such as with Leyland Motors for the Centaur, Cromwell and Comet tank programmes.²⁶ This problem was highlighted by the Deputy Chief of the Imperial General Staff, Lieutenant-General Ronald Weeks when he stated during July 1942 to Sir Miles Thomas of Mechanization & Aero that tank firms were responsible for improving the system of factory inspection.²⁷ In response, Thomas contacted the firms within Crusader production group firms to stress that every completed tank must be capable of meeting the operational requirements of the army.²⁸ However these efforts still produced completed tanks that needed corrective action by fighting units upon being received in the theatre of operations.

To illustrate the problems in both the level and capability of official and factory based standard of inspection, 30 out of 41 Crusader tanks inspected in North Africa during February 1943 needed up to 300 man-hours to correct production faults. The remaining 11 tanks needed between 300 and 500 man-hours to make them battleworthy.²⁹ To put this additional time into context, Crusader manufacturer Mechanization & Aero took 6,050 man-hours to assemble each tank in 1943.³⁰ As a result, the time needed to rectify original production problems by workshop mechanics in the field represented about five per cent of total assembly man-hours and therefore should not be overestimated.

²⁶ BCVM, M632 143/5, General Manager's Meetings, 1941–3, 'General', April 1943.

²⁷ HMC, 80/20/1/7 & 8/19, Weeks to Thomas, 20 July 1942.

²⁸ HMC, Thomas, 80/20/1/1 & 2/1, Thomas to West's Gas; Thomas, 80/20/1/5 & 6/7, Thomas to Fodens; 80/20/1/7 & 8/7, Thomas to Ruston-Bucyrus, all 10 August 1942.

²⁹ NCL, CSAC 80.4.81/G.368/5, Special Supplement, 'Crusader', 6 February 1943.

³⁰ HMC, 80/20/1/1 & 2/8, Mechanization & Aero to Thomas, 'Assembly and Machining Time in Man Hours', 3 January 1944.

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IV

The fourth consideration for industry is that production of obsolete equipment may have to be continued to meet the political decision to help a friend in trouble and to show something tangible was being done to maintain and strengthen public opinion.

Following the German invasion of the Soviet Union in June 1941 the Western Allies provided munitions, equipment and raw materials to their new ally fighting on the Eastern Front from late 1941 until the end of the war.³¹ To show the British public and specifically industry that this programme was both becoming a reality and of vital importance for the British war effort, the Minister of Supply Lord Beaverbrook launched his “Tanks for Russia” week in September 1941. This particular initiative was designed to encourage the British tank industry to increase output so these tanks could be sent to the Soviet Red Army.³²

The information recorded by the Mass Observation surveys identified that British opinion supported the idea of sending British fighting equipment to meet the requirements of the Soviet Union. Essentially, there was a realization that the Soviet war effort took priority over British needs because if the Soviet Union surrendered Britain would again be vulnerable to German attack.³³ There was a consensus among British industry towards the importance of “Tanks for Russia” week and the programme produced an example of good industrial relations between the government, the factory employers, the trade unions and workers themselves.³⁴

To help towards meeting British obligations under the protocols to provide equipment to the Soviet Union, Britain ordered 1,420 Valentine tanks from Canadian industry and all but 32 of these completed vehicles were supplied directly to the Red Army.³⁵ The Valentine tank continued in production until May 1944 and long after the tank was effectively obsolete. This was because the Valentine tank met the demands of the Soviet Union for this particular tank instead of the more recent tank designs now being produced by British industry or from the United States.³⁶ Despite being obsolete, the Soviet Union liked the reliability of the Valentine tank; that it was small and low to the ground which meant it was less of a target on the battlefield; that it ran on a diesel engine in keeping with Soviet tanks for greater simplicity in the supply of fuel; and that there was a greater supply of spare parts for supporting continuous operations.³⁷ To illustrate the impact of continued Valentine production, the number of front line tanks delivered by British industry during 1944 consisted of 2,223 tanks powered by the Meteor engine, 1,062 Churchill tanks and still 280 Valentine tanks to meet the remaining Soviet requirements under the aid programme.³⁸

³¹ See Beaumont, *Comrades in Arms*.

³² NCL, CSAC 80.4.81/G.368/48–52, Harriman to Churchill, 25 May 1943.

³³ Mass Observation Archive, file 885, ‘Seventeenth Weekly Report (New Series)’, 29 September 1941, pp. 2–3.

³⁴ *The Times*, 23 September 1941; *The Times*, 24 September 1941; TNA, AVIA 11/46, Macmillan to Birmingham Railway; Macmillan to Metropolitan-Cammell, 27 September 1941.

³⁵ Historical Section, ‘Tank Production’, pp. 3–5; *Hansard* (Commons), 5th ser., CDXXI, 16 Apr. 1946, cols 2516–19.

³⁶ TNA, WO 32/10521, ‘Supply of Tanks to U.S.S.R.’, 10 March 1942; CAB 120/357, ‘Notes of Points Made in Discussion between Prime Minister and Sir Andrew Duncan’, 23 July 1943; CAB 120/356, ‘A.F.V. Production’, May 1944.

³⁷ TNA, WO 185/6, Military Mission Moscow, 7 August 1942; Hancock and Gowing, *British War Economy*, p. 362.

³⁸ TNA, CAB 120/356, ‘A.F.V. Production’, January to December 1944.

V

The fifth consideration is that industry may need continuation orders for obsolete or unreliable equipment because an enforced cancellation would mean an unacceptable loss of output and disruption of labour resources during the change-over of production. Effectively, the decision had to balance the loss in output by interrupting the existing production run, against the anticipated increase in quality with the introduction of a new model.

The British tank industry experienced this situation with a number of tank programmes throughout the war. The fighting in France in 1940 justified the continuation orders for the Matilda tank, in keeping with the then General Staff emphasis upon heavy armour and armour piercing firepower with the two-pounder gun. However the performance of the Matilda tank was affected mechanical unreliability.³⁹

The continuation orders received by English Electric and Leyland Motors during 1940 and 1941 for the unbattleworthy Covenant tank ensured that these firms incurred ‘no gap in production’ before transferring production to new designs expected during 1943.⁴⁰ Therefore the unreliable Covenant tank remained in production until January 1943 and the now obsolete Matilda tank was produced until August 1943.⁴¹ The reason why production of these out-of-date designs extended far beyond battlefield usefulness was because the tank programme as a whole could only change very slowly. This had the effect of delaying the transfer to a later tank design or other essential war work, like the production of locomotives.⁴² The benefits of redirecting the locomotive tank firms to resume production of their core industry was to avoid importing these bulky machines from the United States and consuming valuable Lend-Lease shipping space.⁴³

An important reason for avoiding inactive production was the retention of labour rather than having workers sent to another firm that required the same manpower. This problem was experienced by the tank industry during the change-over from Crusader programme to the production of the Cavalier or Centaur tanks. For example, while the skilled workers within the Mechanization & Aero production group became inactive at the end of Crusader tank production they were still needed to prepare the transfer to the new tools and jigs required for the machining and assembly of the new Cavalier tank. The unacceptable alternative was to have these workers transferred to the Leyland Motors production group producing the new Centaur tank.⁴⁴

A similar example was experienced within the Churchill tank programme. During 1942 the Churchill contract was extended from 3,000 to 3,500 tanks to avoid a break in production before Vauxhall Motors would start production on the new Cromwell tank.⁴⁵ However production of the Cromwell tank was not ready for mass production until beginning 1944 so an order of 500 additional Churchill tanks of the latest design was agreed for 4,000 tanks in total. As it transpired Vauxhall Motors never transferred to the

³⁹ Bodleian Library Oxford (hereafter BLO), Vulcan Foundry, MS. Marconi 2739, Board Minutes, 1934–40, ‘A.12 Tanks’, 11 June 1940; TNA, WO 185/8, First meeting of the Tank Board, 24 June 1940.

⁴⁰ BLO, English Electric, MS. Marconi 2724, ‘War Diary of the English Electric Company Ltd. March 1938 – August 1945’, 10 December 1940 and 21 March 1941; BCVM, M632 143/5, ‘Comparative Statement of Orders Received’, April 1941; TNA, WO 185/8, Sixteenth meeting of the Tank Board, 23 May 1941.

⁴¹ TNA, AVIA 46/188, ‘Monthly Deliveries’, p. 271; CAB 120/355, ‘A.F.V. Production’, weeks ending 12 June to 7 August 1943.

⁴² TNA, WO 185/8, Third meeting of the Tank Board (Reconstituted), 9 September 1941.

⁴³ TNA, PREM 3/426/15, Lyttelton to Churchill, 28 August 1942; Lyttelton to Churchill, 8 September 1942; Churchill to Lyttelton, 13 September 1942.

⁴⁴ HMC, Thomas, 80/20/6/38 & 39/16, Thomas to Ministry of Labour, 26 August 1942.

⁴⁵ TNA, WO 185/8, Tenth meeting of the Tank Board (Reconstituted), 20 January 1942; Twelfth meeting of the Tank Board (Reconstituted), 17 February 1942; Thirteenth meeting of the Tank Board, 7 May 1942.

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production of the Cromwell tank and continued to produce the Churchill and later Heavy Churchill tank until the end of the war.⁴⁶

The change-over from one tank design to another produced another effect in relation to the supply of the material components for both programmes. Both English Electric and Leyland Motors should have finished their Covenanter tank contract in November 1942 and then move production to the new Centaur tank. However the completion of Covenanter production by these firms and the subsequent transfer to the Centaur tank was delayed until January 1943. This was because the component suppliers shifted their focus to provide equipment to start assembly of the new Centaur tank instead of providing the materials necessary to finish the Covenanter programme first.⁴⁷

VI

The sixth consideration is that to ensure quality output in sustainably high numbers industry should focus on the standardization, specialization and simplification of the production process. Standardization is the production of fewer designs; specialization concentrates production among fewer firms or factories; and simplification involves fewer man-hours to assemble each product. The British tank industry achieved this ability during the second half of the war under a programme that demanded reliable tanks to carry out a mobile role for offensive operations overseas.

The standardization of the British tank programme was achieved from 1943 with the transfer to quality production with the decision to concentrate production among the latest Churchill, Cromwell and Comet tanks. The United States and the Soviet Union demonstrated how the standardization of war production was successfully applied on a much larger scale with the output of vast numbers of Medium tanks.⁴⁸ These two much larger nations also benefited from their industrial centres being located, or relocated in the case of the Soviet Union, safely away from the risk of enemy bombing attack.⁴⁹

For British and Commonwealth tank units fighting on the front line, the standardization of production among fewer designs brought about advantages of mechanical reliability which could not always be relied upon during the first half of the war. For example in North Africa during 1943, Churchill tanks had completed 400 to 700 miles without the same mechanical problems experienced with earlier production models.⁵⁰ This increased performance did not go unnoticed with Lieutenant-General Weeks giving production parent Vauxhall Motors particular praise for the greater quality of factory workmanship.⁵¹ The reliable quality of the Cromwell tank was demonstrated during and after the Normandy campaign in late 1944, when despite being in continuous action for three weeks and with little chance for maintenance, the rate of mechanical failure among these tanks was extremely low.⁵² In addition to the reduced requirement for crew maintenance in the field,

⁴⁶ TNA, CAB 121/261, 'Tank Production by Vauxhall Group', by Grigg and Duncan, 20 January 1943; CAB 65/33/12, War Cabinet, 'Tank Production', 20 January 1943.

⁴⁷ BCVM, M632 143/5, 'Covenanter Tank', August and November 1942, TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

⁴⁸ Murray and Millett, *War To Be Won*, pp. 240, 257, 590 & 598.

⁴⁹ Tooze, *Wages of Destruction*, p. 578; Harrison, 'The Soviet Union: The Defeated Victor', in Harrison (ed.), *Economics of World War II*, p. 295.

⁵⁰ LAC, vol. 2626, file HQS-3352-37-6-1, 'North African Theatre of Operations - A.F.V. Technical Report No. 1', 26 March 1943; TNA, AVIA 11/30, 'A.F.V. Technical Report No. 15', Appendix E, 2 August 1943.

⁵¹ HMC, Thomas, 80/20/5/37/1, Weeks to C. J. Bartlett, Vauxhall Motors, 18 June 1943.

⁵² Staffordshire Record Office, Birmingham Railway Carriage & Wagon Company, D831/1/6/2/M, Routine Correspondence and Letters, Verney to Briggs, 6 September 1944.

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the standardized nature of British tank production meant that tank crews had a greater familiarity with the equipment overall.⁵³

For the specialization of the British tank programme, rather than introducing any new firms to tank assembly, the experience and techniques within the existing production groups were concentrated among fewer tank firms to specialize in carrying out the final assembly. These changes further improved the quality of workmanship in the British tank industry to complement the standardization of production among the battleworthy Churchill, Cromwell and Comet tanks. As a result, between 1943 and 1945 the number of tank firms fell from 27 to 19 following the cancellation of the Matilda and Crusader programmes. This was later reduced again to just 11 core tank firms to focus the standardized production. The other firms returned to their pre-war industrial production of locomotives or wheeled vehicles and others were used for tank conversions, such as the 17-pounder gun Firefly or Duplex-Drive swimming tanks.⁵⁴

The simplification of the tank manufacturing process was achieved with the fewer man-hours necessary to complete the assembly of the standardized designs by the smaller number of specialist tank firms during the second half of the war. To illustrate, at Leyland Motors the Covenanter tank required 6,900 man-hours to complete and Mechanization & Aero recorded that 6,050 man-hours were necessary for each Crusader tank. In contrast to the 18 ton Covenanter and 20 ton Crusader, Leyland Motors reported that the later 28 ton Cromwell tank needed a much reduced 5,640 man-hours to assemble this immediately battleworthy tank.⁵⁵ As a result of the British tank industry producing operationally effective Cromwell tanks in large numbers, they were able to suddenly increase output in response to the front line demands to replace the heavy losses sustained in Normandy during July and August 1944.⁵⁶ This is shown in Figure 4 together with the consequence of delaying the start and rate of output expected from the Comet tank programme designed to replace the Cromwell.

VII

The seventh and final consideration is that industry should avoid becoming over reliant upon the supply of equipment from an overseas source to replace production at home as there is a risk that the amount received could be less than expected or stops altogether.

Right from the onset of war Britain decided to take advantage of the production potential and strategic remoteness of North American industry to supplement manufacturing at home.⁵⁷ Early British orders for American tanks were purchased using cash reserves and gold until superseded by the supply under Lend-Lease.⁵⁸ To illustrate the positive effect that Lend-Lease has upon the supply of equipment to British fighting units, of the 951 tanks shipped to British forces by the end of 1941, only 165 were sent under British cash

⁵³ LAC, vol. 9377, 38/TECH LIA/2/3, '21 Army Group: AFV Technical Report and Reply, No. 17', para. 24, 15 November 1944.

⁵⁴ TNA, AVIA 22/454, 'Centaur/Cromwell Planning', 9 November 1943; 'Tank Capacity', 28 October 1944.

⁵⁵ BCVM, M632 143/5, 'B/X Factory', July 1942; HMC, 80/20/1/1 & 2/8, Mechanization & Aero to Thomas, 'Assembly and Machining Time in Man Hours', 3 January 1944.

⁵⁶ BCVM, M631 143/5, 'General', July 1944; 'General', August 1944; CAB 120/356, 'A.F.V. Production', March 1944 to April 1945.

⁵⁷ Hancock and Gowing, *British War Economy*, pp. 105, 195n, 229 & 382; Stacey, *Arms*, pp. 490–1.

⁵⁸ TNA, AVIA 38/42, 'Launching of the Tank Programme', Appendix V (A): Principal tank contracts placed by British Supply Mission, dated after 1945.

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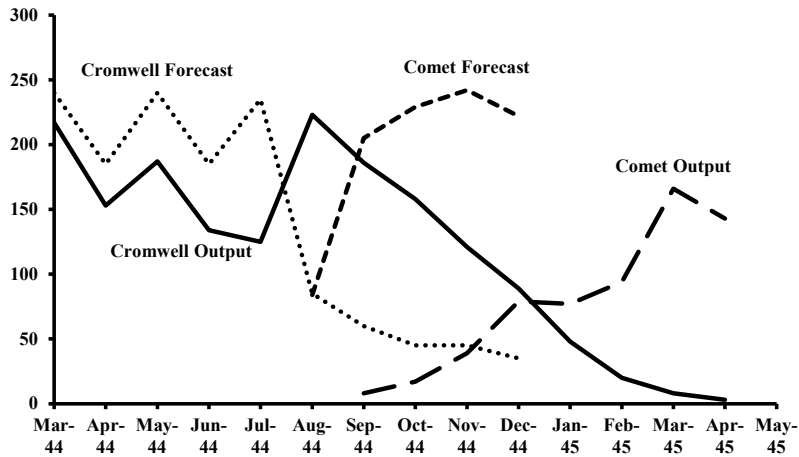


Figure 4. *Cromwell and Comet tank forecasts and output, March 1944 to April 1945*

Sources: TNA, AVIA 22/454, ‘Centaur/Cromwell Planning’, 9 November 1943; CAB 120/356, ‘A.F.V. Production’, March 1944 to April 1945.

contracts.⁵⁹

The supply of good quality Sherman tanks from the United States during 1943 meant that Britain was able to concentrate upon developing the Cromwell tank to a high standard as highlighted already. This meant that the Cromwell tank did not enter mass production prematurely and avoided the problems experienced by the earlier Crusader and Churchill programmes.⁶⁰ To demonstrate the importance of American industry upon the British tank programme, Britain produced 16,712 battleworthy front line tanks from 1942 to 1944, compared to 20,000 Grant and Sherman tanks received from the United States.⁶¹

Britain had clearly become over-reliant upon tanks supplied from the United States during the final years of war. At the start of 1944, Britain reduced their tank programme to just over 5,280 tanks with the expectation of 8,500 tanks from the United States.⁶² By November 1944, the British tank programme was cut even further when the four firms producing the Comet tank received reductions in their contracts under the expectation that the war in Europe would be finished by the end of March 1945.⁶³ These reductions were made on the understanding that Britain would receive nearly 8,961 Sherman tanks under Lend-Lease during 1944.⁶⁴

However, as shown in Figure 5 by October 1944 there was already a shortfall of 3,469 Sherman tanks under this arrangement with a total of 5,492 deliveries against the expected 8,961.⁶⁵ This situation deteriorated further when no Sherman tanks were received during

⁵⁹ Stettinius, *Lend-Lease*, p. 94.

⁶⁰ S. C. on National Expenditure (P.P. 1946), p. 50.

⁶¹ TNA, AVIA 46/188, ‘Monthly Deliveries’, p. 271; CAB 120/355, ‘A.F.V. Production’, 1943; CAB 120/356, ‘A.F.V. Production’, 1944.

⁶² TNA, BT 87/137, ‘Tank Policy’, by Grigg and Duncan, 12 January 1944.

⁶³ TNA, AVIA 22/454, ‘Curtaiment of Production of Cromwell, Comet, Challenger & S.P.2’, 14 November 1944.

⁶⁴ TNA, PREM 3/427/9, ‘Tank Production in 1945’, 6 October 1944.

⁶⁵ TNA, CAB 120/356, ‘A.F.V. Production’ January to December 1944; BT 87/137, ‘Assignments from U.S. War Department’, by P. J. Grigg, 15 December 1944.

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November or December. The reason for this shortfall was because of the understandable reaction by the United States to give new production Sherman tanks directly to American instead of to British tank units in order to replace the heavy losses sustained by both armies during and after the Normandy campaign.⁶⁶ As a result in January 1945, Britain reversed the earlier reductions in the Comet tank programme to ensure that the enough tanks were provided to British units until the end of war.⁶⁷

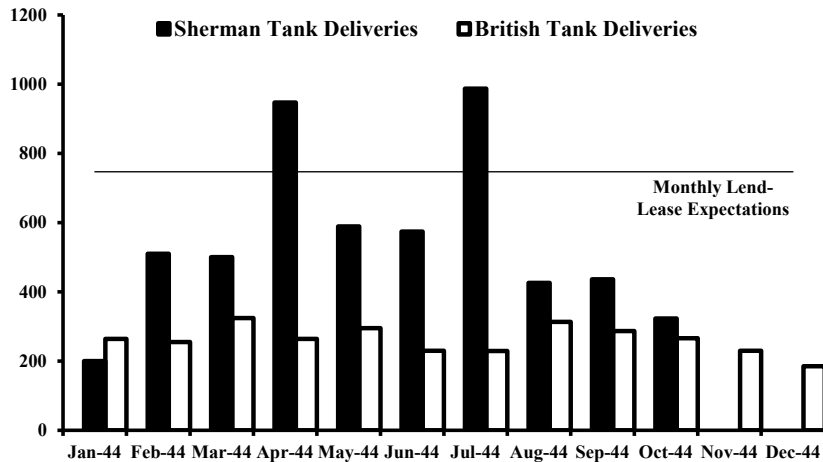


Figure 5. *Monthly deliveries of Sherman and British front line tanks during 1944, compared to the expected delivery of Sherman tanks under Lend-Lease*

Sources: TNA, CAB 120/356, 'A.F.V Production' January to December 1944; BT 87/137, 'Assignments from U.S. War Department', by P. J. Grigg, 15 December 1944.

Conclusion

By reviewing the experience of the British tank industry, the different governmental, military, organizational and international considerations can be discovered within the context of the war economy. The pressures of war demanded the mass production of equipment from all the countries involved. Britain encountered organizational problems when changing industry from a position of peace to a war footing. A large number of British civilian firms were quickly transferred to tank production. The British tank industry took time to achieve the eventual mass production of quality tanks that gave front line units with reliable and extremely mobile tanks that could carry out successful offensive operations overseas.

The eventual transition to quality production over the course of the war was achieved by overcoming a series of difficulties which can still apply during peacetime. To begin with there were too many tanks deemed "unfit for action" for too long prompting the government to increase the production of spare parts necessary for tank units to maintain battleworthy vehicles in the field. There was a lack of official inspectors required to check

⁶⁶ TNA, BT 87/137, BAS and BSM to Ministry of Supply and War Office, 6 December 1944.

⁶⁷ TNA, AVIA 22/454, 'Amendment', Director-General of Armoured Fighting Vehicles, C. Gibb to Regional Controllers, 15 December 1944.

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the quality of workmanship in the factories which only checked the fully assembled vehicle. This was in contrast to the aircraft industry which inspected the work in progress, so faults within the tank production process were overlooked. Furthermore, the government had to issue continuation orders for tanks that were superfluous, obsolete or unbattleworthy because the transfer to the latest design would have caused a break in production and disrupted labour resources prior to the change-over.

From the strategic perspective, continuation orders were also necessary to supply the Soviet Union with the desired Valentine tank together with the assistance of Canadian production long after this tank was needed for British requirements. The supply of tanks from the United States was very positive and meant that British industry transferred production to the Cromwell tank without being rushed into service. However, Britain became over reliant upon tanks from the United States and they cut back the tank programme by too much and too soon before the war ended.

In relation to the tank industry, the shortages of labour and materials meant that the British tank firms could not achieve the desired rate of output during the first half of the war. This was overcome by the successful transfer of British industry to quality tank production by the standardization, specialization and simplification of the tank programme.

To summarize, the experience of the British tank industry during the Second World War had similarities in the industries of the United States and Canada. It can therefore be said that the British experience of producing tanks was in no way unique and that peacetime industry can benefit from this understanding to become more productive and commercially successful.

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Table 2. *Tank Specifications*

Tank	Max. Weight (Tons)	Main Gun	Max. Armour (mm)	Max. Range (Miles)	Total Output	Production Dates
<i>Britain</i>						
Matilda	26.5	2-pdr	78	160	2,908	1939-43
Covenanter	18	2-pdr	40	100	1,770	1940-3
Crusader	20	2-pdr 6-pdr	66	100	4,917	1940-3
Valentine	18.5	2-pdr 6-pdr 75 mm	65	90	7,041	1940-4
Churchill	38	2-pdr 6-pdr 75 mm 95 mm	102	90	4,276	1941-4
Centaur	28	6-pdr 95 mm	76	165	1,774	1942-4
Cromwell	28	6-pdr 75 mm 95 mm	101	175	2,547	1942-5
Cavalier	26.5	6-pdr	76	165	497	1943-4
Heavy Churchill	40	75 mm 95 mm	152	90	917	1943-5
Sherman DD	32.5	75 mm 76 mm	75	125	693	1944
Sherman Firefly	35	17-pdr	75	125	2,074	1944-5
Comet	35	77 mm	101	125	623	1944-5
<i>Canada</i>						
Valentine	18.5	2-pdr	65	90	1,420	1941-3
<i>United States</i>						
Grant / Lee	29	37 mm & 75 mm	75	160	6,258	1941-2
Sherman	32.5	75 mm 76 mm	75	150	44,300	1942-5

Note: Figures include the production of both standard gun tanks and those models converted to a supporting role.

Sources: TNA, CAB 102/851, ‘Brief Particulars’, October 1944; AVIA 46/188, ‘Monthly Deliveries’, pp. 269-71; CAB 120/355, ‘A.F.V. Production’, 1943; CAB 120/356, ‘A.F.V. Production’, 1944 and 1945; Historical Section, ‘Tank Production in Canada’, p. 2; Chamberlain and Ellis, *British and American Tanks*; Ness, *Jane’s World War II Tanks*, pp. 86-8 & 187.

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