Lessons learned?
Securing essential materials in changing global value chains: British raw material planning and dependencies on Germany in the tungsten value chain in the interwar period

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Complications in the fight against the Covid-19 virus raise the question of whether lessons can be learned from the current pandemic for a future one. For example, the disruption of global value chains revealed a dependence on Asian countries for urgently needed products, such as face masks or medical devices. As a result, some have claimed that domestic production of such essential products is necessary. If countries have their own production of face masks and medical devices, will this ensure that if a pandemic breaks out in the future they will be prepared and there will be no shortages of essential products?

Answers may lie in British raw material planning in the interwar period. The First World War also disrupted international value chains, which led to shortages and revealed dependencies that had to be overcome. At the end of the First World War, Britain learned their lesson and aimed to remain independent in strategical raw materials in order to avoid the shortages that occurred in the First World War in future conflicts. Using the example of the British dependencies on Germany in the tungsten value chain, I will show that changing value chains pose a major challenge for the objective of being independent and that companies have a key role in overcoming this challenge.

I follow a qualitative historical analysis of mainly British and German sources, among others, reports and memoranda of British committees and correspondence and contracts of British and German companies. These were located in state and city archives as well as various private company archives in Britain and Germany.

With its empire, Britain had access to sufficient ore deposits for almost all metals. However, that did not mean that Britain was independent from other countries. Dependencies mostly arose further down the value chain, in refining or processing into alloys. Since Germany was an enemy during the First World War and considered as a potential enemy in the 1930s, dependencies on Germany were seen as especially problematic. Dependences arose, for example, in the tungsten value chain. During the First World War, Britain was dependent on the German tungsten processing industry, a dependency she overcame with the construction of her own processing industry. However, in the 1930s, Britain became dependent on Germany again, this time further down the value chain, in the production of cutting materials. Companies and government organizations, however, drew different lessons.

In the beginning of the twentieth century, a revolutionary cutting material, high-speed steel, was implemented. This material accelerated industrial production and was immensely important for armaments. Cutting tools, a term that refers to tools that shape other material through cutting, grinding, drilling, etc., played an important role in mass production. The material of cutting tools needs to be harder than the material which the tool cuts. In addition, it must be heat-resistant as the cutting process causes the material to run hot. Tungsten can improve both, since it is both the element with the highest melting point and it is one of the hardest elements. This made tungsten a crucial component in high-speed steel, which soon became its major use. As the name already suggests, high-speed steel enabled cutting tools to run with higher speed, which increased productivity by four to five times.[1] The gain in labour productivity particularly increased the production of munitions, where the cutting, grinding and drilling of hard materials was an essential process. Thus, high-speed steel was immensely important for the attrition wars of the twentieth century.[2] It was deemed one reason for Germany's unexpected high production of armaments during the First World War.[3]

High-speed steel was already widely used in British munition factories when the war broke out. The war further increased the demand of the material. However, the British production of high-speed steel suddenly stopped because the British producers could not procure the tungsten powder and ferro-tungsten they needed for their production. Britain had more than enough tungsten in their empire, but the step in the tungsten value chain in charge of producing tungsten powder and ferro-tungsten from tungsten concentrates was under the control of Germany. Germany was the leading country in tungsten metallurgy with a world share of approximately 65 per cent in 1913.[4] In 1914, German traders were supplying up to 90 per cent of Britain's processed tungsten needs, mainly tungsten powder and ferro-tungsten.[5] When the high-speed steel industry was cut off from German supplies, it became a problem not only for Britain but for all of the Entente powers.[6] The solution was to fill the gap in the value chain with a tungsten processing industry on British ground. Consequently, in 1915, works for tungsten processing were quickly constructed in Britain under Government assistance, together with the leading steel producer.[7] The production of high-speed steel was resumed. Britain controlled the tungsten value chain from mining to the cutting material and was no longer dependent on Germany.

After the war, the demand for high-speed steel, and therefore for processed tungsten, fell sharply. To prevent further factory closures, the government decided to protect the British tungsten processors in order to maintain an industry that would be important in the case of a conflict and should therefore remain in British hands. Thus, tungsten and its compounds were included in the Safeguarding of Industries Act of 1921 with import duties of 33 1/3 per cent *ad valorem* at first for five years. After that, tungsten processing continued to be protected, not least because it was claimed by the British tungsten processing industry, with the argument made that they solved a severe shortage during the First World War and that tungsten processing should not fall into German hands again.[8]

In the 1930s, Britain faced again a similar dependency problem, this time further down the value chain. Another revolution in the improvement of cutting tools occurred. The use of the cutting material, tungsten carbides, instead of high-speed steel, increased productivity again tremendously. In addition, less tungsten was needed.[9] Tungsten carbide is made of tungsten and carbon. It was invented in Germany. In 1926, the German company Krupp got a patent on the tungsten carbide Widia. Its name

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[1] Lloyd-Jones and Lewis (2006), *Alfred Herbert Ltd. and the British machine tool industry, 1887-1983,* p. 23.

[2] Emeny (1937), *The strategy of raw materials,* p. 77.

[3] Li and Wang (1947), *Tungsten,* p. ix. See also: Köster (1935), *Die Bedeutung der physikalischen Chemie für die Metallindustrie*, p. 388.

[4] See for example: Rothelius (1929), *Om världskonsumtionen av wolframmalmer,* p. 82.

[5] Limbaugh (2010), *Tungsten in peace and war, 1918-1946,* p. 15.

[6] Einecke (1930), *Das Wolfram in der Weltwirtschaft,* p. 40.

[7] Rothelius (1929), '*Om världskonsumtionen av wolframmalmer*', pp. 82–3.

[8] See for example the request of Arthur Balfour, managing director of the ferro tungsten producing Balfour and Company, for the prolonging of the import duty. Extracts from a letter, dated 9th December 1930, from Sir A. Balfour, Kt., K.B.E., to Mr. Ashley, Board of Trade, British National Archives, *NA SUPP 3/73*.

[9] Meyer (1969), *Wolfram,* p. 25. Stevens (1999), *World War II economic warfare,* p. 539. Giffard (2015), *A Hard Sell: Factors Influencing the Interwar Adoption of Tungsten Carbide Cutting Tools in Germany, Britain, and the United States*, p. 896.

derives from ‘WIe DIAmant’ (like diamond), which refers to its exceptional hardness. Since tungsten carbide is harder and more heat resistant than high-speed steel, cutting tools can run even faster. High-speed steel cutting tools were limited to around 75 to 80 feet per minute. With tungsten carbide tools, 500 to 1,000 feet per minute were possible.[10] Krupp started production in Germany already in 1926.[11] Soon, the company expanded successfully to foreign markets. In doing so Krupp did not just sell the patent but controlled foreign production. In this way, Krupp exercised a far-reaching influence also on British tungsten carbide production. At first, Krupp sold Widia in Britain through Wickman, a British machine tool trader and later also a producer. Then, in 1930, Wickman and Krupp jointly founded a company, to exercise Krupp’s British patent rights, the Tool Metal Manufacturing Company of Coventry (TMMC). TMMC not only granted licenses but also set production quotas for Widia.[12] Moreover, Krupp was very restrictive in granting patents. In some cases, British companies were not granted licenses because they had opposed Krupp in the First World War.[13] Krupp's restrictive licensing and setting of production quotas slowed the adoption of tungsten carbides in Britain. In addition, some British tungsten carbide producers were dependent on supplies of tungsten carbide powder from Krupp. The British tungsten processors were not able to gain control of the production of tungsten carbide powder.[14]

In Germany, tungsten carbides were adopted much faster than in Britain, with the support of the government. Since Germany was dependent on foreign tungsten ore, the use of tungsten carbides requiring less tungsten compared to the use of high-speed steel played an important role. According to Krupp, the annual production of carbide tools in Germany between 1928 and 1938 was three to eight times higher than in Britain, in relation to the national steel production. A post-war British intelligence report agreed that ‘the German output of hard metal [tungsten carbides] has always been many times that of this country even allowing for the difference in population’.[15]

The British government underestimated the importance of tungsten carbides for the armament industry; they did not support its application before the outbreak of the Second World War; and they did not take action against dependencies on German firms. In government reports, tungsten carbides were often not given any particular importance.[16] The Supply Board, a British government organization for planning of industrial capacities, learned lessons from the First World War: Probably with the experience of the construction of a tungsten processing industry during the Great War in mind, the Supply Board argued in 1931 that tungsten carbides ‘could be produced in any required quantities at short notice’. Seven years later, the Supply Board still took the same view.[17]

One company drew another lesson. The machine tool producer Alfred Herbert, who took on the role as Controller for Machine Tools in the Ministry of Munitions during World War One, wrote a memorandum on the lessons of the war for a future emergency. Alfred Herbert recognised the importance of tungsten carbide and concluded ‘The production obtainable by the use of these materials is so much greater than by that obtained from steel tools that it is of the utmost importance to ensure adequate supplies.’[18]

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[10] Aldcroft (1966) *The Performance of the British Machine-Tool Industry in the Interwar Years*, p. 288.

[11] Kolaska (2007), *Hartmetall - gestern, heute und morgen*, pp. 827–8.

[12] Giffard (2015), *A Hard Sell: Factors Influencing the Interwar Adoption of Tungsten Carbide Cutting Tools in Germany, Britain, and the United States*, pp. 909–12.

[13] Toni Pierenkemper (2002), *Von Krise zu Krise*, 233.

[14] Tweedale (1995), *Steel City*, p. 223; United States. Committee on Military Affairs (10 March 1943), *Hearing*, p. 360.

[15] Giffard (2015), ‘*A Hard Sell: Factors Influencing the Interwar Adoption of Tungsten Carbide Cutting Tools in Germany, Britain, and the United States*’, pp. 897–8. See also: *Deutschland, England, U.S.A.* Undated internal document of Krupp. Krupp Archive *WA 146/731*.

[16] Board of Trade Supply Organisation (July 1928), Memorandum on the Ferro-Alloys, p. 13, British National Archives, *NA MUN 4/5447*. Committee of Imperial Defence: Principal Supply Officers Committee (15 April 1930) Control of materials during the war. Memorandum prepared in I. & M. Department, *NA SUPP 3/48*.

[17] Giffard (2015), *A Hard Sell: Factors Influencing the Interwar Adoption of Tungsten Carbide Cutting Tools in Germany, Britain, and the United States*, p. 920.

[18] Alfred Herbert (undated), Notes on the control of machine tools, small tools and gauges during the last war, with suggestions for the future, Coventry Archives *CA PA2567/10*.

Consequently, Alfred Herbert took initiative himself and started a collaboration with British Thompson-Houston (BTH) for the production of tungsten carbide.[19] Both companies tried to get the license not directly from Krupp but through a pooling arrangement from General Electrics, USA, who hold the patent of a similar tungsten carbide, Carboloy, which ultimately also came from Krupp. However, Krupp saw that their patent in Britain had been violated and brought the case to court. Krupp succeeded and BTH had to pay for a license.[20] Nevertheless, BTH and Alfred Herbert built up a tungsten carbide production, independent from German supplies, using materials form the British Empire, and, in addition, they created large stocks.[21]

In spite of Alfred Herbert's efforts, after the outbreak of the Second World War, Britain was faced with a similar situation as in the First World War. Alfred Herbert wrote to the Ministry of Supply that production will not be able to meet the demand.[22] A US report from 1943 complains about 'drastic shortages', stating that the use of tungsten carbide was 'one of the great secrets of German rearmament' and 'without tungsten carbide it would have taken the Reich twice as long to achieve half the results'.[23] The shortages of tungsten carbide resulted also from the fact that the deliveries of tungsten carbide powder from the German company Krupp stopped.[24]

The example of the tungsten value chain shows that in a world of constant technological progress and changing trade relationships, new challenges arise that require new answers. After the First World War, Britain wanted to prevent dependencies on Germany for strategic materials in any future conflict. The production of tungsten powder and ferro wolfram had been protected: The gap in the tungsten value chain remained closed. Then, Krupp invented Widia and created a new market that changed the value chain. As a consequence, elsewhere, another gap opened up and created a similar problem which did not result in the intervention of the British government.

As Trentmann (2008) points out, to intervene, the government first needed an agreed justification, such as the necessity to protect key industries for national security; furthermore, an industry had to ask for an intervention.[25] In this framework, the industry of tungsten powder and ferro-tungsten, borne out of the shortages of the First World War, asked for protection, stating that it would protect key industries. Consequently, the government protected the tungsten processors.

With the invention of tungsten carbide in 1926, there came a new material that was not known during the First World War. The material was underestimated as a strategic material because shortages slowing down the production of munitions had not been experienced in the First World War. In addition, companies that received the licence from Krupp benefited from the collaboration with the German firm. From a profit perspective, they had no interest in asking for protection. However, Alfred Herbert was an exception. As a machine tool producer, he was aware of the importance of the new material and since he worked for the government during World War One, he also aimed to remain independent from Germany.

This clearly shows that raw materials policy is not just a matter for the government but is also an interaction between various actors: politicians, government organisations and companies. All actors can draw different lessons. The information advantage that private companies often have in recognizing new challenges means that companies are particularly important actors in raw materials policies.

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[19] Letter of M.Louis, patent lawyer, to George B. Cooke of Bristows, Cooke & Carpmael, 14 Sept. 1936. Krupp Archive, *WA 57 B 3607*. See also: Giffard (2015), *A Hard Sell: Factors Influencing the Interwar Adoption of Tungsten Carbide Cutting Tools in Germany, Britain, and the United States*, p. 911.

[20] Ibid., p. 905.

[21] Ibid., 920; *Wimet and Ardoloy Metal Alloys,* The Engineer, 19 Feb. 1937, pp. 230.

[22] Letter from Alfred Herbert to, Arthur Albert Rowse, Director of Machine Tools by the Ministry of Supply, 25 Nov. 1939. Coventry Archives *CA PA2567/4/41-67*.

[23] United States. Committee on Military Affairs (10 March 1943), *Hearing*, p. 330.

[24] Ibid., 360.

[25] Trentmann (2008), *Free trade nation,* pp. 293–6.

These conclusions may also be true for lessons in the fight against Covid-19. If a country wants to be independent from other countries in the production of essential products, it is not enough to produce only the end-product, but to control the whole value chain. As the present example around Widia in the 1930s has shown, technical innovations can change value chains and create new dependencies. In recognizing these dependencies, private companies play a key role due to their market knowledge. This requires an intensive exchange of information between companies and authorities. However, since conflicts of interest can hinder the exchange of information, the responsibility lies not only with the authorities but also with private companies.