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ARTICLE

Industrial Transitions in the Black: US Government-Business Relations in the Mobilization of Carbon during World War II

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This article examines government–business relations in the context of World War II mobilization of the US carbon black industry. The topic contributes to the ongoing debates about whether this relationship laid the foundation for postwar US prosperity. The primary research question is: What role did wartime mobilization and the US government play in carbon black industrial transitions and changes in technology and productivity? The evidence from wartime records of the carbon black program shows that industry dominated the government–business relations during the period. The War Production Board was unable to effectively resolve or even report on disputes between synthetic rubber and carbon black industry factions or resist carbon black industry control over product prices and specifications and approval of government-financed plant construction projects. Behind the transition was prewar and wartime carbon black industrial research and development. Through the federal government's cooperative research, procurement, and sponsored construction contracts, the carbon black industry applied its industrial research discoveries to transform its business model to high-efficiency production in the context of postwar expansions of transportation infrastructure, economic growth, and natural gas pipelines.

Introduction

This study focuses on government–business relations during World War II mobilization of the US carbon black industry. This period of mobilization is of interest because of the industry's dramatic changes in production capacity, increasing by about 70 percent (by weight) from 1941 to 1945, and an increase in product yield from less than 5 percent in 1942 to over 24 percent in 1945.[1] The period under study also featured the invention of the manufacturing technology that would subsequently be used to increase production yields to nearly

1. Total factor productivity growth reported in the 1919–1929 period is the highest in the entire period of 1919–2000, including for three carbon black-related industries: chemicals and allied products, petroleum and coal products, and rubber and miscellaneous plastic products. The channel process produced the most carbon black (by weight) in 1941 until the furnace process supplanted it (by weight of product) in 1950.

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70 percent. The purpose of this study is to illuminate issues in the history of government–business relations during World War II industrial mobilization. The primary research question is: What role did wartime mobilization and the US government play in carbon black industrial transitions and changes in technology and productivity?

Both Alexander Field and Robert Higgs have claimed that World War II mobilization did not lay the foundation for postwar US prosperity. For Field, it was the rapid and incomparable advances in electrification and reconfiguration of the factory in the 1920s that led to enormously high rates of growth in manufacturing during the Great Depression (1929–1941).[2] This advance, along with buildout of surface road infrastructure and expansion of car and truck production, provided the foundation for the US economic and military success during World War II and postwar consumption.[3] In Higgs's reassessment of the US economy in the 1940s, it was a case of planned chaos in both process and legacy, with much of the US government's wartime investments having have little or no value after the war.[4] Similarly, Hugh Rockoff argues that attempts to link postwar American prosperity to the capital construction during the war are likely to be disappointing, except for some government spending on industrial plant and equipment, such as synthetic rubber factories.[5]

Robert Gordon argues against the 1920s as the breakthrough decade. Although the Great Depression played a role in leading to the New Deal, unionization, rising wages, and shorter work hours that helped boost productivity growth, the less speculative cause of growth was "the productivity-enhancing learning-by-doing that occurred during the high-pressure economy of World War II. Production miracles during 1941–1945 taught firms and workers how to operate more efficiently, and the lessons of the wartime production miracle were not lost after the war: productivity continued to increase from 1945 to 1950.[6] Gross and Sampat also found wartime productivity growth, although through learning-by-research. In their study of investments by the US Office of Scientific Research and Development, they found that large, positive effects on wartime invention and build-up of scientific and technological capabilities set postwar innovation in motion.[7]

Other scholarship on US World War II industrial mobilization has emphasized the gradual and incremental nature of the change versus a disjunctive transformation of American society and establishment of the United States as an economic and military superpower.[8] In these works, the midcentury transformation of the relationship between government and industry was influenced by the federal government's New Deal recovery program and the floating of the dollar between 1933 and the 1970s.[9] Behind postwar innovation and economic prosperity was not just government mobilization investments but also Great Depression financial regulations, highly skilled immigrants fleeing Nazi Germany, and private financing of innovation.[10] In this

2. Field, *Great Leap*, 52–53; Field, "Impact of the Second World War," 690.
3. Field, *Great Leap*, 19.
4. Higgs, *Wartime Socialization of Investment*, 507; Higgs, *Wartime Prosperity*, 41; Higgs, *Depression, War, and Cold War.*
5. Rockoff, "Ploughshares to Swords," 82–88.
6. Gordon, *Rise and Fall of American Growth*, 18.
7. Gross and Sampat, *Inventing the Endless Frontier*, 3.
8. Hooks, *Forging the Military-Industrial Complex*; Sparrow, *Warfare State.*
9. Carew, *Becoming the Arsenal.*
10. Schuelke-Leech, and Leech, "Innovation in the American Era of Industrial Preeminence."

narrative, the change wrought by mobilization was mitigated because the War Production Board had to work against the strong alliance of the armed forces and corporate America.[11]

This article begins with a review of the literature on World War II mobilization, with a focus on the US synthetic rubber program that identifies the context for the research question. An overview of the carbon black industry from 1864 to 1989 follows, which sets the stage for the transition that occurred in World War II. Next, the War Production Board's organization and activities are presented, including financing of new plants, setting the terms for procurement of carbon black, and managing the supply crisis that began in 1943. The following sections examine the growth in carbon black production from 1942 to 1945 and the Truman Committee's Senate investigation of carbon black shortages in 1945. I conclude that the industry dominated government–business relations and carbon black mobilization, and that the government's War Production Board was less powerful and competent than others have suggested. This government approach of paying for plants and carbon but otherwise taking a hands-off approach to the industry was used by the carbon black firms to accelerate transitions to high-efficiency technology developed in their research laboratories from 1921 to 1945, preparing them to meet the anticipated postwar demand for tires and other rubber goods.

US World War II Mobilization and the Synthetic Rubber Program

Investigations of World War II mobilization are uncovering the details of how the US government and private sector firms altered the course of technological development.[12] Scholarship has explored novel combinations of research, new product development, collaborative testing, and user training.[13] The outcomes were not just new wartime goods but also changes to research and innovation methods, such as collapsing testing and deployment into a single experimental procurement phrase to meet urgent mobilization timelines.[14] Technological innovation challenges also led to new standardization activities for the national economy.[15] This occurred as the United States began to catch up with the standard-setting taking place in Germany and the Soviet Union.[16] Behind this accelerated approach to research and development (R&D) were technical committees that were financed by War Production Board, consisting of stakeholders from the government and a variety of industries.[17]

One of the best-known cases of wartime government-industry technological R&D is the US synthetic rubber program. This provides context for the study, given the lack of carbon black industrial histories and that there are strong similarities in the carbon black and rubber industries during World War II. Both are fields of chemistry, chemical engineering, and material science. Both carbon black and synthetic rubber products are manufactured industrial goods made from fossil fuels that are used in the production of consumer rubber goods

11. Koistinen, *Planning War, Pursuing Peace*; Waddell, "Economic Mobilization for World War II."
12. Bernstein and Wilson, "New Perspectives."
13. Margolin, "United States in World War II," 29.
14. Berk, "Problem-Solving State."
15. Olshan, "Standards-Making Organizations," 321.
16. Yates and Murphy, "Engineering Rules."
17. Timmermans and Epstein, "World of Standards," 71.

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(i.e., those containing materials other than rubber). American firms were the largest-scale producers of products in both markets in the nineteenth century, and they continued in this position for a generation after World War II. The biggest market for both industries in terms of revenue and tons of product was (and is) tires. During World War II, firms in both industries built on prior inventive work to develop new products and production methods that laid the technological foundation for postwar industrial expansion. In the years before World War II, US crude annual rubber consumption was about 600 million tons.[18] US carbon black production was just under 300 million tons in 1941, mostly through the traditional channel process. Rubber production increased in 1945 to about 922 million tons, by and large from synthetic rubber plants.[19] From 1941 to 1945, carbon black increased to just over 500 million tons, with nearly half of the production from new gas furnace plants. Prices of both products were (and are) determined by weight and varied by grade, sales volume, and other factors. In 1945 carbon was priced at 5 cents per pound ($100 per ton) and synthetic rubber at 17.50 cents per pound ($350 per ton).[20]

The extensive body of scholarship on synthetic rubber arises from its enduring role as a model for government-sponsored innovation and mobilization as well as science-based industrial growth and management.[21] Here, "innovation" means the first attempt to carry out a new idea in practice. The new knowledge from the US government-sponsored wartime synthetic research program was built on the 1929 discovery by I. G. Farben researchers that Buna-S synthetic rubber (combining butadiene and styrene) when mixed with carbon black was significantly more durable than natural rubber.[22] The owner of the US patent rights to Buna-S was Standard Oil of New Jersey. Under threat of prosecution from the US government, Standard Oil made its patent available to US rubber firms on a royalty-free basis from early 1942 and for the duration of the war. However, Standard Oil lacked the know-how to manufacture Buna-S.[23] As a consequence, the government-sponsored research program focused on developing a basic recipe to make rubber from butadiene and styrene. The major commercial synthetic rubber—called Government Rubber Styrene (GR-S)—was developed in 1942 after researchers discovered the conditions, chemicals, and types and amounts of carbon black and rubber to compound in manufacturing products crucial for wartime mobilization.

The resulting growth in synthetic rubber manufacturing made the trajectory of World War II mobilization possible. By the end of World War II, the US government had financed 96 percent of synthetic rubber production capacity and employed about twenty-four thousand operators

18. Wendt, "Control of Rubber in World War II."

19. Koistinen, *Arsenal of World War II*, 149.

20. "Synthetic Rubber Boom Predicted," *New York Times*, February 25, 1945, 66. All prices in the article are in nominal dollars. At present, the materials are priced per ton in the range of $1,000 for carbon black and $2,500 for synthetic rubber. US Bureau of Labor Statistics, *Producer Price Index by Commodity: Chemicals and Allied Products:* Carbon Black [WPU06790918], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WPU06790918; US Bureau of Labor Statistics, *Producer Price Index by Commodity: Rubber and Plastic Products: Synthetic Rubber, Including Styrene-Butadiene Rubber (SBR) and Ethylene Propylene* [WPU07110224], retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/WPU07110224

21. Long, "History of Rubber," 493 and 498; Woodruff, "Growth of the Rubber Industry."

22. American Chemical Society, *United States Synthetic Rubber Program*, 2.

23. Tuttle, "Synthetic Rubber 'Mess,'" 22.

in fifty-one plants.[24] By 1949 most of these government-owned production plants were sold to operating firms for less than 50 percent of the government investment.[25] At the turn of the twenty-first century, the $60 billion international rubber industry had about fifteen thousand establishments operating in the United States, with about 70 percent of synthetic rubber descended from GR-S.[26]

Most of the accounts of the US wartime synthetic rubber program written in the 1940s and 1950s considered it a triumph of worldwide significance. Success was attributed to the improvement of German Buna-S rubber by American firms applying principles from the new discipline of chemical engineering.[27] Crucial factors were the extreme wartime necessity and the cooperation among industry scientists and engineers to pool ideas and experimental data from thousands of experiments and hundreds of road tests.[28] The federal government was credited for the erection of plants once general agreement was reached on the synthetic rubber production process.[29] The most critical assessment of the program was from the economist Robert Solo, who famously claimed the results of the synthetic rubber program to be "zilch, zero, nothing."[30]

Scholarship in the 1980s found a mix of success and failure in the US synthetic rubber program. There was success in improving and producing synthetic rubber on a large scale due to wartime emergency factors.[31] However, the program was not without issues, and it failed after 1945.[32] According to Arthur Squires, the fundamental problem was that the government failed to provide leadership and direction.[33] The historian William Tuttle characterized the government program as a success nevertheless beset by "ill-informed executive leadership; inadequate scientific and technical advice; political strife between the White House and Congress," as well as lobbyists and presidential administrative vagaries and avoidance of issues.[34] Paul Koistinen judged the wartime program as a success of government financing of mass production that was also "plagued by weak, ineffective, or irresponsible leadership."[35]

Histories in the last dozen years have also emphasized the effectiveness of federal government managers who financed and regulated wartime supply chains and the military-industry juggernaut.[36] Even for those historians who acknowledge the complexity and convoluted

24. Higgs, "Wartime Socialization of Investment," 501.

25. Jones, *Fifty Billion Dollars*, 316, 415, and 454; Samuelson, "US Government Synthetic Rubber Program," 8; Solo, "Sale of the Synthetic Rubber Plants."

26. American Chemical Society, *United States Synthetic Rubber Program*, 1.

27. Howard, *Buna Rubber*, vii and 203. Howard, an engineer and lawyer at Standard Oil Company (in New Jersey), directed oil research and development, patenting, and manufacturing activities for the firm.

28. Roberts, "Rubber Industry," 78–79.

29. Toulmin, *Diary of Democracy*, 126

30. Solo, "Saga of Synthetic Rubber," 35; see also Solo, "Research and Development in the Synthetic Rubber Industry," 79.

31. Morris, *American Synthetic Rubber Program.*

32. Herbert and Bisio, *Synthetic Rubber*, 215; American Chemical Society, *United States Synthetic Rubber Program.*

33. Squires, *Tender Ship*, 149–157.

34. Tuttle, "Birth of an Industry," 64.

35. Koistinen, *Arsenal of World War II*, 148.

36. Wilson, *Destructive Creation.*

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nature of mobilization, there remains an emphasis on senior government leadership.[37] Finlay, in *Growing American Rubber*, claims that mobilization of synthetic rubber occurred in the context of an internationalist interpretation of the postwar world that prevailed over the nationalist schemes.[38] In choosing petroleum-derived Buna S over renewable domestic resources, American industry and the federal government positioned the United States for leadership in the postwar global economy and exploitation of any economically viable resource, without territorial limitations on the new global superpower.

Prewar R&D has also been featured as a critical factor.[39] The economist Hugh Rockoff, in his study of US war economies, found the synthetic rubber program a success and "the most compelling example of what seems like a technology brought into being by the war."[40] Yet it was largely a success of a speedy mobilization since the fundamental discoveries occurred in the 1920s and 1930s. The war created the economic conditions to produce synthetic rubber on a commercial scale and over a period of two years versus what would have been over at least a decade during peacetime. Both Koistinen and Rockoff noted that the fundamental discoveries occurred before the war, as early as 1879, with commercial breakthrough in 1937.[41]

The literature on mobilization and the wartime synthetic rubber industry emphasize the prewar and wartime political, scientific, technological, economic, and cultural forces behind the innovation and scale-up in the second and third transitions in the carbon black industry. To address these forces, this case study focuses on the following questions: Was the industrial development of carbon black consistent with broader changes happening in chemical industries, including prewar industrial R&D as a critical factor, including the prior development Buna-S rubber for wartime synthetic rubber production? Was the US federal government's War Production Board carbon black program a powerful force in the transitions, for example, in sponsorship of research or standard-setting exercises? Did the federal government's financing and regulation of wartime carbon black drive innovation and scale-up? Did wartime scientific research with the rubber industry give rise to the dominant carbon black production technology from the 1950s to the present? To what extent did expectations of postwar expansion of automotive consumption and natural gas grids propel technological innovation?

Carbon Black Industry, 1864–1999

Carbon black is a soot-like substance produced from the thermal decomposition or partial combustion of oils, hydrocarbon gases, animal bones, resins, and other combustibles. It is used as an industrial product in the manufacture of a wide variety of end-products, including eye makeup, inks, tires, paints, and plastics. Printer's ink was carbon black's biggest market since the advent of the printing press; that is, until tires took that spot in the early twentieth century.

37. Klein, *Call to Arms.*
38. Finlay, *Growing American Rubber*, 196.
39. Arora and Gambardella, "Implications for Energy Innovation."
40. Rockoff, *America's Economic Way of War*, 229.
41. Koistinen, *Planning War, Pursuing Peace*, 124–125. Rockoff, *America's Economic Way of War*, 231–233.

Global markets for carbon black grew with the rise of the automobile and the discovery of the reinforcing properties of carbon black in rubber in 1904,[42] and its capacity to extend average tire life tenfold or more.[43] By 1918 sales of carbon black to the US rubber industry reached approximately 9,000 tons per year, surpassing printer's ink by about half the tonnage.[44] Following World War I, the growth in US automobile manufacturing led to an increase in production of channel black to more than 45,000 tons by 1923 and nearly 225,000 tons in 1941.[45] For the thirty-year period following World War II, the carbon black industry sold approximately 95 percent of its domestic product to rubber companies.[46] As industry scaled-up productions, prices fell from $2.50 per pound in the 1860s to 8 cents in 1920, 4 cent in 1930, and 3.26 cents in 1941.

The structure of the US industry changed from many small producers in the late nineteenth century to five large privately held chemical firms in the 1940s: Godfrey L. Cabot Inc., Columbian Carbon Company, General Atlas Carbon, J. M. Huber Inc., and United Carbon Company. These firms and their subsidiary companies manufactured more than 95 percent of US carbon black during World War II.[47] They worked within a highly competitive supply chain between the oil and gas industries (which supplied feedstock for manufacturing) and rubber and other industries (which purchased material to manufacture tires and other goods).

From the 1930s to 1940s, the Phillips Petroleum Company was the dominant gas supplier to the carbon black industry, delivering 40 percent to 60 percent of the gas—mostly residue gas from manufacturing gasoline—for carbon black production in the United States. Its discovery of Texas's huge Panhandle Field in 1918 brought carbon black companies westward to the burgeoning natural gas industry.[48] Phillips used its leverage to negotiate ownership or control of 50 percent of the stock of manufacturing subsidiary companies of Cabot, Columbian, United, and Witco Chemical.[49] Phillips also struck deals with carbon black firms so that it was not paid in cash for its gas but granted a percentage of carbon black produced, which it then sold through carbon black producers.[50] In addition, it hosted a leading carbon black industrial research laboratory and was a contributor to the US synthetic rubber program by operating a synthetic rubber manufacturing plant in Borger, Texas.

42. Melsom, "50 Years."

43. Shearon, Reinke, and Ruble, "Oil Black," 685. The incorporation of carbon black resulted in tire treads with increased abrasion resistance and retarded oxidation which, left unchecked, restricted the life span of rubber to only two or three years after its manufacture. In 1908 an automobile tire cost from $35 to $125 and was usually good for only two thousand miles of service. By 1936 it cost between $8 and $25 and lasted for twenty-thousand miles, on average.

44. Neal and Perrott, *Carbon Black*, 8 and 60.

45. Hopkins and Backus, "Carbon Black" (1941), 1171–1177.

46. The annual information on carbon black production, yield, and pricing is from "Carbon Black," reports printed in the annual *Minerals Yearbook* published by US Geological Survey from 1918 to 1977. For scholarly uses of the data file, please contact the author.

47. Peter J. Connolly, assistant chief counsel, and Francis D. Flanagan, chief investigator, "Carbon Black," 3, dated April 24, 1945, Record Group 46, Box 1047, Archives I, National Archives and Records Administration (hereafter, NARA).

48. Wallis, *Oil Man*, 157.

49. US Special Committee Investigating the National Defense Program, "Tentative Report on Carbon Black Investigation," June 16, 1945, 21, Record Group 46, Box 1047, Archives I, NARA.

50. Connolly and Flanagan, "Carbon Black," 7, Record Group 46, Box 1047, Archives I, NARA.

The carbon industry has had three primary manufacturing processes since transitioning from craft-based lampblack production in the late nineteenth century. The first is the channel method of production, invented in 1864. It was first used commercially in West Virginia in 1872, and it grew with the rise of the US oil industry in the late 1860s and 1870s.[51] This process allowed large volumes of natural gas that would otherwise be released into the atmosphere during oil extraction to be solidified and thus monetized.[52] The second is the gas furnace process, invented in 1921 and developed throughout the 1920s and 1930s to improve production yield and performance characteristics.[53] Instead of open flames in drafty channel-method burner houses, gas furnace reactors were enclosed for higher process control and efficiency. Texas and Louisiana commissioned the first two gas furnace plants in 1928.[54] The third process also uses enclosed reactors, but the primary feedstock is oil, not natural gas. The oil furnace process was first used in commercial practice from 1942 to 1944. It offered even higher yields than gas reactors and overtook channel and gas furnace reactor production in 1952 in terms of total annual weight of production.[55] The third process moved from natural gas to oil not only because of oil's higher yields of carbon but also because firms discovered how to produce a greater range of products from oil and because of changing natural gas and oil prices. Natural gas prices in the United Stated increased 2.8 times from 1945 to 1960 while oil prices increased 2.4 times.[56] The oil furnace process is still the dominant production process.

Behind the research and innovation in the late 1930s and early 1940s was the industry's awareness that by the mid-1940s it would exhaust its mainland frontiers for cheap natural gas. For the previous eighty years, the availability of stranded gas assets in West Virginia, Kentucky, Louisiana, Texas, and other states meant that the industry's carbon black plants were highly transient, and competition was driven by first-mover advantage into territories with newly discovered oil and gas resources.[57] As the geographical frontiers were exploited and natural gas pipelines extended into oil- and gas-producing areas to bring natural gas to new industrial, commercial, and residential users, competition increasingly focused on developing intangible properties and being the first to the patent office and to license to firms that arrived later.[58] The rising costs of natural gas and dramatic growth in the tire market created strong incentives for industrial research laboratories to offer their firms a unique competitive advantage by radically increasing production efficiency.[59]

51. Neal and Perrott, *Carbon Black*, 3–8.

52. Cabot, "Manufacture of Carbon *Black*," 658.

53. Drogin, *Developments and Status of Carbon Black*, 12. The first invention appears to be "Method and Apparatus for Producing Carbon Black," US Patent No. 1,738,716, filed January 5, 1921, and issued December 10, 1929. Isaac Drogin says the first invention appeared in 1922.

54. Shearon, Reinke, and Ruble, "Oil Black," 686.

55. Shearon, Reinke, and Ruble, "Oil Black," 686.

56. From 1945 to 1960, the wellhead price of natural gas increased from 5 cents to 14 cents per mmbtu while crude oil increased from $1.22 to $2.88 per barrel. Based on information from the US Energy Information Association, *Independent Statistics and Analysis*, "US Natural Gas Wellhead Price," https://www.eia.gov/dnav/ng/hist/n9190us3a.htm.

57. Neal and Perrott, *Carbon Black*, 3–4; Lott, Backus, and Tyler, "Carbon Black" (1945), 195.

58. Barreca, Clay, and Tarr, *Coal, Smoke, and Death*.

59. Schmookler, "Economic Sources of Inventive Activity."

There was tremendous employment growth in US carbon black industrial research from the late 1930s and into the 1940s. Table 1 shows the growth in industry directors, chemists, physicists, engineers, technical personnel, and other personnel from 1921 to 1946. Over that period, the structure of R&D organizations grew from two modest laboratories, made up of mostly chemists, to thirteen operations with employment growth in all jobs, with "other personnel" making up the largest job category. While the largest percentage increase in staff occurred between 1927 and 1938, with a nearly eight-fold increase, the biggest jump in total number of staff occurred between 1940 and 1946.

In this way, the US carbon black industry differed from the rubber industry, which matured earlier. In 1921 three of the big four rubber firms (the United States Rubber Company did not publish staffing data) had 465 research staff versus only 10 in carbon black (Table 2). Firestone, Goodrich, and Goodyear, meanwhile, collectively expanded staff as they transitioned from natural to synthetic rubber products and process. In particular, the number of chemists expanded during wartime while the number of engineers dramatically decreased in these laboratories.

This growth in carbon black research staff is related to the increase in the percentage of carbon black patent filings per decade from the 1930s to 1950s. Table 3 shows carbon black industry patent filings growing from the 1920s to its peak in the 1960s, when it moved through the second and third manufacturing processes just discussed, before declining from the 1970s to the 1990s.

Table 1. US Carbon Black Firm Research Staff, 1921–1946

Year	1921	1927	1931	1933	1938	1940	1946
Directors	2	4	7	6	11	12	23
Chemists	1	10	31	32	99	126	202
Physicists	0	1	1	1	6	7	15
Engineers	3	5	8	5	23	52	106
Laboratory and technical personnel	3	1	9	29	53	50	92
Other personnel	1	3	17	1	9	31	233
Total	10	24	73	74	201	278	671

Sources: US National Research Council, *Research Laboratories in Industrial Establishments of the United States*; US National Research Council, *Industrial Research Laboratories of the United States*, for years 1927, 1931, 1933, 1938, 1940, and 1946.

Table 2. Firestone, Goodrich, and Goodyear Research Staff, 1921–1946

Year	1921	1927	1931	1933	1938	1940	1946
Directors	10	21	31	28	17	35	15
Chemists	68	97	117	127	189	224	232
Physicists	9	10	20	30	16	30	34
Engineers	87	94	152	165	277	177	55
Laboratory and technical personnel	86	52	73	223	432	259	105
Other personnel	205	434	481	749	371	567	195
Total	465	708	874	1322	1302	1292	636

Note: The big four rubber firms were Firestone Tire & Rubber Company, including its subsidiary Xylos Rubber Co.; B. F. Goodrich Company; Goodyear Tire & Rubber Company; and United States Rubber Company.
Sources: US National Research Council, *Research Laboratories in Industrial Establishments of the United States*; US National Research Council, *Industrial Research Laboratories of the United States*, for years 1927, 1931, 1933, 1938, 1940, and 1946.

Table 3. US Carbon Black Industry Firm Patenting, 1920–1999

USPTO Assignee	1920–29	1930–39	1940–49	1950–59	1960–69	1970–79	1980–89	1990–99
Binney and Smith	—	8	5	—	—	—	—	—
Godfrey L Cabot & Cabot	5	14	18	52	111	25	19	170
Columbian Carbon	10	10	24	47	30	4	9	10
Continental Carbon	—	2	1	7	41	15	2	—
General Atlas Carbon	1	6	—	—	—	—	—	—
J. M. Huber Inc.	1	8	19	19	26	36	27	18
Phillips Petroleum	3	10	94	362	373	346	204	61
United Carbon	—	5	9	5	8	—	—	—
Witco Chemical	—	—	—	—	2	4	1	—
Total	20	63	170	492	591	430	262	259

Note: Patents are categorized by filing date.
Source: US Patent and Trademark Office.

Table 4. US Big Four Rubber Firms Synthetic Rubber Patenting, 1920–1999

USPTO Assignee	1920–29	1930–39	1940–49	1950–59	1960–69	1970–79	1980–89	1990–99
Firestone Tire & Rubber	–	3	85	62	30	39	49	38
B. F. Goodrich	4	55	251	104	39	30	25	8
Goodyear Tire & Rubber	1	–	1	60	56	133	86	90
United States Rubber	–	26	151	222	68	–	–	–
Total	5	84	488	448	193	202	160	136

Note: Patents are categorized by filing date.
Source: US Patent and Trademark Office.

Likewise, Table 4 illustrates the dramatic growth in the 1940s in patenting of synthetic rubber inventions by the big four US rubber firms (Firestone, Goodrich, Goodyear, and United States Rubber Company), although with a plateau in the 1950s and then sharp drop off in the 1960s.

Patent filings by carbon black firms from the 1930s to 1950s protected new products fit-for-use with synthetic rubber as well as incremental improvements to the natural gas furnace process and disruptive oil furnace reactors. The oil furnace reactor, invented just prior to World War II, borrowed designs from the natural gas furnace and introduced new conditions to use oil as the primary feedstock. The first invention using the reactor was in 1938 by a paint and pigments manufacturer.[60] Philips then acquired the patent application, as it had begun research into the oil furnace reactor process in 1937. Dr. Joseph C. Krejci, a chemical engineer at Phillips, independently invented and first implemented a commercially successful reactor process to reinforce rubber.[61] The initial Phillips patent application was filed in December

60. J. W. Ayers, *Manufacture of Amorphous Carbon,* US Patent No. 2,292,355, filed June 28, 1938, patented August 11, 1942.
61. McKetta, *Encyclopedia of Chemical Processing and Design*, 188–189.

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1942.[62] By 1943 the process was operational at the Phillips plant in Borger, Texas. Cabot also developed an oil furnace process more than a year before the start of its synthetic rubber program in 1942.[63] It was reduced to practice at Cabot's government-financed plant in Guymon, Oklahoma, which was owned by the firm and leased to the War Production Board for a dollar per year.

World War II was the critical period for invention and commercialization of the oil furnace process and the increased production capacity of the natural gas furnace process. These were the tangible and intangible foundations for take-off in production during the second half of the twentieth century. Figure 1 shows the changes in production in the US carbon black industry from 1867 to 1976. Figure 2 shows production yield rates for channel, gas furnace, and oil furnace processes. The production yield is the percentage of carbon in the feedstock (natural

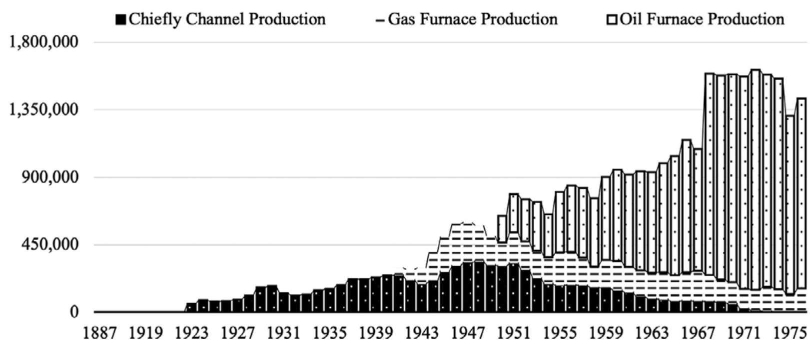

Fig. 1. US Carbon Black Production of Primary Processes in Tons, 1887–1975.

Source: Author' compilation from information in the "Carbon Black" sections of *Minerals Yearbook*. See Minerals Yearbook for the years 1931 to 1942, 1944 to 1976, and Neal and Perrott, *Carbon Black*.

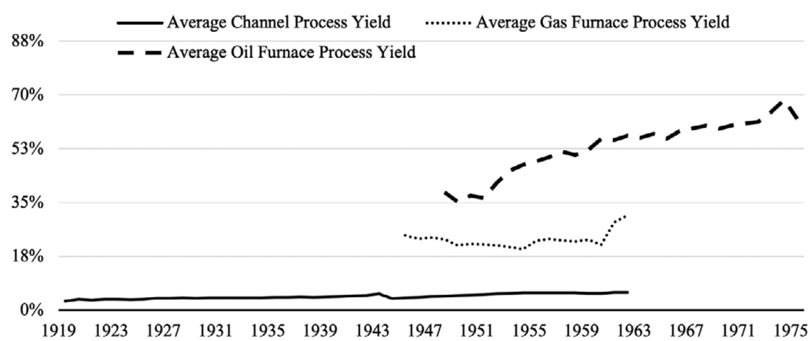

Fig. 2. Carbon Black Production Yields of Select Processes, 1919–1975.

Source: Same as Figure 1.

62. J. C. Krejci, *Carbon Black Process and Apparatus*, US Patent 2,419,565, filed December 14, 1942, patented April 29, 1947. It cites the Avers patent as one of three items of prior art.

63. Cabot, "Short History of Cabot Corporation," 124–125.

gas or oil) contained in the final product.[64] Channel yields for rubber reinforcing grades of carbon black were limited to around 5 percent. Some channel black yields were as low as 1 percent, such as for colorants. Meanwhile, natural gas furnace yields ranged from 10 percent to 30 percent and oil furnace black yields were 35 percent to 68 percent. By the 1970s, the dominant process was the oil furnace and yields for the industry approached 70 percent.

The War Production Board and Carbon Black Program

Japanese control of Southeast Asia after December 1941 and for the rest of the war resulted in American firms losing 90 percent of their natural rubber supply. On August 6, 1942, President Roosevelt appointed a committee to study the rubber situation and recommend action. The Report of the Rubber Survey Committee, issued to Roosevelt on September 10, 1942, concluded that without synthetic rubber, US stocks would be depleted by 1943. To address this likely exhaustion of supply, the committee recommended development of a synthetic rubber program to add rubber capacity by converting existing refineries, constructing new plants, and erecting alcohol plants needed for synthetic rubber manufacturing.[65] No mention was made of the carbon black feedstock for rubber production.

This was instead addressed by the War Production Board. In operation from January 1942 to the surrender of Japanese forces in 1945, it oversaw the conversion of industries from peacetime work to war production, controlled scarce materials, and prohibited nonessential production. It also directed the carbon black program, executed contracts to purchase carbon black for military rubber production, and financed and built new carbon black plants. The line of authority for synthetic rubber and carbon black ran from President Roosevelt directly to the chairman of the War Production Board (Donald Nelson) and to the director of the Office of the Rubber (William Jeffers) and his deputy rubber director (Colonel Bradley Dewey).[66] Under Dewey were assistant deputy directors in charge of plant construction, operations, technology, R&D, and raw materials for synthetics. The carbon black interests in the War Production Board reported to Dr. Edwin Richard Gilliland, the assistant deputy director for raw materials for synthetics.[67] Reporting to Gilliland were the (1) Chemicals Division of the War Production Board, which determined the chemical needs for the war program (Dr. David Morgan, director of Chemicals Division, and William Twombly, assistant director); (2) the Carbon Black Manufacturers Industry Advisory Committee; (3) the Carbon Black Technical Industry Advisory Committee; and (4) Thomas Starkie, the chief of the Paint and Pigment Section of the Chemicals Division.[68]

Starkie was a dollar-a-year man and vice president of Witco Chemical Company, a carbon black manufacturer. He had worked in the carbon black industry since 1921 and been hired by

64. The other carbon in the feedstock produced heat or other gas products and was vented according to practices during the World War II era.

65. Conant, Compton, and Baruch, *Report of the Rubber Survey Committee*, 3–4.

66. Wendt, "Control of Rubber."

67. Gilliland was a chemical engineering faculty member at the Massachusetts Institute of Technology from 1934 to 1973 and head of the Chemical Engineering department from 1961 to 1969.

68. Reynolds, "Production Requirements of the Chemical Industry."

the Chemicals Division in 1942. As the chief of Paint and Pigment for the government, he determined the carbon black needs of rubber manufacturers and acted as the government's presiding officer of the Carbon Black Manufacturers Industry Advisory Committee. Within the War Production Board, he tracked carbon black industry operations and yields, required carbon black companies to wire weekly carbon black production reports on a plant-by-plant basis, considered foreign plant operations, oversaw all expansion and construction projects, and was the voice on behalf of the industry at meetings.[69]

The Carbon Black Manufacturers Industry Advisory Committee was formed in 1942.[70] It included representatives from six of the largest carbon black companies: Cabot, Columbian, J. M. Huber Inc., United, General Atlas Carbon, and Continental. In addition, it included a representative of Phillips, the president of Carbon Black Export Inc. (the exporter of the six major groups), and the treasurer of National Gas Products Association. The committee's role was to advise the War Production Board and its Chemicals Division on matters of interest to the industry. Among its core concerns were that the government purchase more gas furnace black and increase the price of channel black. Illustrative of the committee's influence within the War Production Board—from May 26, 1943, and onward—was its power to approve any project involving carbon black construction costs totaling more than $100,000.[71] This would become an issue taken up by a Senate investigation.

The other industry committee was the Carbon Black Technical Industry Advisory Committee. Members were R&D directors from the six major carbon black firms as well as representatives from the Chemicals Division, the Office of the Rubber Director (which would become a major opponent of carbon black interests in the War Production Board), and the Division of Industry Advisory Committees. They met to discuss matters such as how to develop composite pigments and the requirements for buying more gas furnace black and increasing the price of channel black.[72]

Carbon Black Processes and Production, 1942–1945

Although the carbon black industry had seen significant growth from the end of the Civil War to 1941, the industrywide approach to testing of both carbon black and its use in rubber goods manufacturing was closer to its post-Civil War roots. It was only in 1952 that the industry formed a Carbon Black Advisory Committee to develop uniform chemical testing procedures.[73] Prior to 1952, each carbon black company and each rubber company had their own testing protocols and nomenclature for carbon black products.

69. "Memorandum from Michael J. Deutch to the members of the Interagency Committee on Carbon Black," March 26, 1945, Record Group 250, Box 413, Archives II, NARA.

70. Carbon Black Technical Industry Advisory Committee, "Summary, November 12, 1942," 61, Record Group 250, Box 416, Archives II, NARA.

71. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14075.

72. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14075.

73. Melsom, "50 Years."

Thus, the call from the Rubber Reserve Company in early 1942 to develop an interindustry testing program for novel carbon black and synthetic rubber materials presented challenges.[74] The goal of the program was to determine the performance of goods made from a variety of grades of carbon black and a variety of new grades of synthetic rubber. This meant considering ratios of synthetic rubber to carbon black and other chemicals as well as the mixing procedures to be employed. It is a testament to the wartime conditions that, immediately following the attack on Pearl Harbor, all of the major carbon black companies began a cooperative research program with the rubber industry to study the carbon black requirements of synthetic rubber.[75] Samples from a variety of grades of channel black and furnace black were tested to determine the properties of various rubber goods.

The results suggested that carbon black had a critical role in all synthetic rubbers, particularly in the dominant synthetic rubber formulation for wartime production: GR-S.[76] Government Rubber Styrene, it was learned, required more carbon black than natural rubber. The testing also confirmed that the smaller particle size channel black better reinforced tire treads and other rubber products requiring toughness and strength to resist wear. While the gas furnace process produced more carbon black per unit of natural gas than the channel process, up to six times more by weight, it was also found that the gas furnace black were not fully reinforcing of synthetic rubber.[77] They were softer and more flexible than the hard channel blacks. The natural gas furnace carbon blacks did poorer in tests for tensile strength, tear strength, rupture energy, and tearing energy. They were better suited for use in tire carcasses (the inner structure of the tire), inner tubes, and rubber goods in which high carbon content, ease of processing, flexibility, and low heat generation were important.

The results of the testing program spurred R&D of new production processes and grades of gas and oil furnace black. This included the oil furnace black, or Philblack process.[78] It offered greater reinforcing properties than semi-reinforcing (SRF) grades made from natural gas, although the price of oil relative to natural gas during the period made it costly to manufacture. In 1942 Phillips patented a gas furnace grade called high modulus furnace black.[79] Columbian Chemicals' researchers developed the fine furnace black grade in 1942.[80] Both of these gas-furnace blacks were, however, found to be less reinforcing than the channel black and primarily suitable for tire carcass and mechanical rubber goods, with some application as pigments.[81] Moreover, these furnace grades required higher air–gas ratios, and the additional air in the reactor meant more carbon combustion and thus lower carbon yields, in the range of 10 percent

74. D'Ianni, "Fun and Frustrations with Synthetic Rubber," 68; Rongone, Frost, and Swart, "Incorporation of Carbon Black," 131; US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13863.

75. Cohan, "Carbon Black in War and Peace," 2079.

76. Garvey and Freese, "Effect of Carbon Blacks."

77. W. Smith, "Carbon Black."

78. J. C. Krejci, *Carbon Black Process and Apparatus*, US Patent 2,419,565, filed December 14, 1942, patented April 29, 1947.

79. J. C. Krejci, *Carbon Black Process and Apparatus,* US Patent 2,375,797 A, filed March 27, 1942, patented May 15, 1945.

80. W. Bryan and H. Braendle, *Manufacture of Carbon Black*, US Patent US2378055A, filed June 27,1942, patented June 12,1945.

81. McKetta, *Encyclopedia of Chemical Processing and Design*, 188–189.

to 15 percent. Beyond the development of new production methods and grades of carbon black, wartime research did not materially affect the yield of channel production. While the overall industry yield had nearly doubled from about 3 percent in 1919 to nearly 6 percent in 1962, little gain was made during World War II; the yield was 4.3 percent in both 1939 and 1946.

Although the results of the experimental development and testing program were broadly reported, there was not consensus as to the percentages of furnace black and channel back to be used in compounding synthetic rubber for use in tires.[82] Given the tight supply of reinforcing channel black, one solution was to build more channel black plants. Another was to build higher efficiency furnace plants and blend SRF gas furnace black with reinforcing channel black. The Carbon Black Manufacturer's Industry Advisory Committee claimed that the rubber industry wanted more channel plants and channel black because it was priced lower than furnace black (initially 3.3 cents per pound for channel black versus 5 cents per pound for furnace black).[83] The Chemicals Division supported the view of the carbon black industry and urged greater amounts of higher priced furnace black. In November 1942 the War Production Board, following the advice of the Chemicals Division, started construction of furnace black plants. The result was the growth in gas furnace production from 50,000 tons in 1941 to 200,000 tons in 1944 (see Figure 1). Channel black production, meanwhile, declined from about 250,000 tons in 1941 to 210,000 in 1944.

The other major element of the War Production Board's carbon black plan, in addition to the testing and construction programs, was to execute fixed price contracts for purchase and delivery of carbon black to claimant agency customers in the US Army and US Navy, for the Canadian Rubber Controller, and for lend lease. The fixed price contracts meant carbon black suppliers could profit from reduced costs of production. The average price for carbon black (channel and furnace) was 2.9 cents per pound in 1940 and 3.26 cents per pound in 1941. At the start of the wartime program, furnace black was selling to claimant agencies for 5 cents per pound and channel black for 3.3 cents per pound. Furnace black was, however, cheaper to produce, given an average yield of about 24 percent versus an average yield in channel black production of about 4 percent, even though both used natural gas as the feedstock. Because of rising natural gas prices during the war and lower margins for production black, the Carbon Black Manufacturers Industry Advisory Committee, based on a recommendation from Starkie, advocated for a price increase of channel black to 4.5 cents per pound.[84] In January 1944, the committee warned the War Production Board that low prices for channel black would risk shortages of supply for the war effort.[85] By July 1944 they succeeded in raising the price for channel black to 5 cents per pound.[86]

82. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13830 and 13853.

83. Carbon Black Manufacturers Industry Advisory Committee, "Summary of Meeting," May 19, 1944, Record Group 250, Box 413, Archives II, NARA.

84. Carbon Black Manufacturers Industry Advisory Committee, "Summary of Meeting," Record Group 250, Box 413, Archives II, NARA.

85. Carbon Black Manufacturers Industry Advisory Committee, "Summary of Meeting," January 19, 1944, Record Group 250, Box 416, Archives II, NARA.

86. US Special Committee Investigating the National Defense Program, "Tentative Report on Carbon Black Investigation," June 16, 1945, 28, Record Group 46, Box 1047, Archives I, NARA.

Although the fixed-price purchase contracts and plant construction and expansion projects increased production and efficiency, it was not enough to prevent a crisis in carbon black supply to the rubber industry. Furnace black shortages occurred as early as November 1942.[87] By summer 1943, it was clear to officials in the War Production Board that the "carbon black production rate was not sufficient to meet the needs of the synthetic rubber program."[88] The *Wall Street Journal* began reporting on stockpile declines in September 1943.[89] By May 1944 issues with production made front-page news as options for Russian and Iranian supply were floated.[90] In spring 1944, Colonel Bradley Dewey, successor to Jeffers, repeatedly told Donald Nelson of "the urgent necessity for taking definite steps to secure increased production of carbon black."[91] Colonel Dewey requested additional projects to produce 100,000 tons of channel black.[92] The Chemicals Division disputed the request, calling for 100,000 tons of furnace production.[93] In June 1944, Nelson, based on recommendations from the Chemicals Division, compromised and ordered 50,000 tons of furnace and 50,000 tons of channel black.[94] The compromise was not enough to meet demand. Some of the deliveries were canceled by carbon black firms (because of the lack of approval for new construction projects from the Carbon Black Manufacturers Industry Advisory Committee) and other deliveries were reduced or delayed. The result was that Jeffers, as the rubber director, increased production requirements in 1944 while the deliveries of carbon were reduced to about one-third.

In December 1944, carbon black shortages made national news.[95] By January 1945, members of the Carbon Black Manufacturers Industry Advisory Committee were pointing to low channel black prices as the key factor.[96] In response, reductions in rubber consumption began in January 1945. By February, the shortages had moved to the front page of the *Wall Street Journal*.[97] In March the stockpile of carbon black was gone.

87. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13881.

88. US Special Committee Investigating the National Defense Program, "Carbon Black Shortage," 12, Record Group 250, Box 415, Archives II, NARA.

89. "Use of Carbon Black for Synthetic Rubber Reduces Inventories," *The Wall Street Journal*, September 11, 1943, 4.

90. "Carbon Black Makers Asked to Weigh Building Plants in Russia and Iran," *The Wall Street Journal*, May 23, 1944, 1.

91. US Special Committee Investigating the National Defense Program, "Carbon Black Shortage," 15, Record Group 250, Box 415, Archives II, NARA.

92. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14071.

93. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13885.

94. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14072.

95. "Shortages, Chiefly in Rayon Cord and Carbon Black, to Plague Rubber Industry During 1945, Says King," *The Wall Street Journal*, December 30, 1944, 2; "Rubber Program Faces Obstacles: Krug Declares Raw Material Shortages," *New York Times*, December 30, 1944, 12.

96. Carbon Black Manufacturers Industry Advisory Committee, "Summary of Meeting," January 19, 1944, Record Group 250, Box 416, Archives II, NARA

97. "WPB Reduces Use of Carbon Black Monthly By 10 Million Pounds," *The Wall Street Journal*, February 15, 1945, 1. Two more front-page stories followed in April.

The War Production Board responded in March to form an Interagency Committee on Carbon Black to solve the shortage problem. Its initial plans included surveying all carbon black plants with a goal of increasing overall production yields.[98] Kenneth Watson, an engineer in the Office of Production Research and Development, visited carbon black manufacturing plants in March and April 1945 with the goal of identifying and sharing technical best practices to reduce the large difference in yields, with some as great as 50 percent among plants with similar processes and identical natural gas. Watson met with little success. Columbian and Phillips declined to discuss their oil furnace operations and refused to participate in cooperative pilot plant trials with other furnace plant operators.[99] Watson also organized a carbon black industrywide visit to a leading channel black plant to share operating techniques to increase output, but it was canceled at the last minute, illustrating the strong industry resistance to share trade secrets even during the national carbon black supply crisis.[100]

Since cooperative projects among carbon black manufacturers were not workable options, the War Production Board sought to boost production through more construction projects. By April 1945, pending approval from the Construction Bureau, there were construction projects for an additional seven channel furnaces, seven natural gas furnaces, and five oil furnaces.[101]

Senate Truman Committee Investigation of Carbon Black Shortages

The crisis drew the attention of the US Senate's Special Committee to Investigate Contracts Under the National Defense Program, known as the Truman Committee. It was formed in 1941 and initially headed by Senator Harry Truman (D-MO) to investigate problems of US war production, such as waste, inefficiency, and profiteering. Senator James Mead (D-NY) took over in August 1944, after Truman resigned to focus on campaigning for the vice presidency. Serving under Truman and Mead were a number of Democratic and Republican senators. One of its early investigations was into shortages of aluminum in 1941.[102] The committee found the shortages were attributable to the reluctance of Aluminum Company of America (Alcoa) to oversupply the market and the Office of Production Management's failure to seek suppliers other than Alcoa. Improvements in the terms of the contract with Alcoa and securing production capacity from other suppliers helped the government get the vast amount of material needed for aircraft production. A similar supply shortage arose with magnesium in 1943, which the Truman Committee investigated. In this case, Dow Chemical was the sole US producer, and it was similarly concerned with oversupply risks and impact on its

98. Memorandum from Deutch to Interagency Committee on Carbon Black, March 29, 1945, Record Group 250, Box 413, Archives II, NARA; US Office of War Information "News Release: Fourteen Steps to Increase the Production of Carbon Black," March 29, 1945, Record Group 250, Box 413, Archives II, NARA.

99. Kenneth M. Watson, "Technical Survey of the Carbon Black Situation," April 6, 1945, Office of Production Research and Development, 6 and 7, Record Group 250, Box 416, Archives II, NARA.

100. Watson, "Technical Survey," ii.

101. Facilities and Inspection Branch, Production Division, War Production Board, "Carbon Black Program," prepared April 11, 1945, and revised April 21, 1945, Record Group 250, Box 413, Archives II, NARA.

102. Toulmin, *Diary of Democracy*, 82–89.

profitability.[103] The Office of Production Management, initially unaware in early 1941 to the risks of a sole-source contract, addressed supply issues by contracting with other companies to build plants with their own capital along with financing from the federal government.[104]

The Truman Committee's public hearings into the carbon black shortage were announced on May 2, 1945, and begun on May 4, 1945.[105] A confidential report prepared in advance of its hearings for the six senators representing the Truman Committee was scathing. The report found the carbon black industry unpatriotic in its price fixing and war profiteering. It concluded that it was inexcusable that the War Production Board, its Chemicals Division, and Interagency Committee on Carbon Black were allowing industry priorities and price fixing over the interests of the war effort. The underlying problem was the alleged oligopolist practices of Cabot, Columbian, Continental, Phillips, and United, and the industry's arrangement with Phillips. The Senate investigators alleged that Phillips was working hand-in-glove with the producers to increase the price of natural gas and receive an increased price for carbon black because it was paid for its natural gas not with cash, but carbon black.[106] The confidential report also pointed to the influence wielded by the dollar-a-year man Starkie from Witco Chemical. In short, it alleged the Chemicals Division parroted the view of the carbon black industry by urging smaller amounts of channel black and greater amounts of furnace black so firms could achieve greater profit from the 5 cents per pound for furnace black (versus the 3.3 cents per pound for channel black).

The initial hearings were held over five days, from May 4 to May 14, 1945. Senator Hugh Mitchell (D-WA) presided over the six senators who represented the Truman Committee at the hearing, three from each party.[107] The committee members were withering in their command of witnesses and questions to discover the truth of the shortages, particularly why there had been a 25 percent reduction in treadwear of jeep tires at the warfront.[108] This approach reflected the senators' professions and experiences. Sen. Harley Kilgore (D-WV) was a criminal court judge from 1933 to 1940. Sen. Harold Burton (R-OH) would serve on the Supreme Court from 1945 to 1958. The sharpest line of questions came from Sen. Homer Ferguson (R-MI), a former circuit court judge from 1929 to 1942 and a professor of law at Detroit College of Law from 1929 to 1939. After the war, Peter Connolly, assistant counsel to the Truman Committee, would prosecute organized crime as assistant solicitor for United States Post Office.

The Truman Committee wanted to know who was responsible for the shortages. As one witness after another evaded responsibility, an exasperated Kilgore called out to simply learn the name of the man in charge.[109] Earl Babcock, director Firestone's Chemical Laboratory, said

103. Wilson, "Making 'Goop' Out of Lemons," 14–15.

104. Toulmin, *Diary of Democracy*, 89–100.

105. By this time, Truman was the vice president to Roosevelt. US Special Senate Committee Investigating the National Defense Program, *Carbon Black Shortage*, Record Group 250, Box 415, Archives II, NARA.

106. Connolly and Flanagan, "Carbon Black," 3, Record Group 46, Box 1047, Archives I, NARA.

107. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13829.

108. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13833–13848.

109. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13853.

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responsibility for the failure to deliver carbon black was with the government's Chemicals Division under Dr. Morgan. Under questioning from Kilgore and Mitchell, Morgan and his assistant director, William Twombly, said the major factor in the underproduction of channel black was price, reflecting the view of the carbon black manufacturers.[110] Testimony at the hearings revealed that Phillips Petroleum had flatly told the Office of Price Administration that it must be paid 3.5 cents per thousand cubic feet for its natural gas or they would not supply it for carbon black production, even though they were supplying natural gas to their subsidiary firms at 1.2 cents per thousand cubic feet during the same period.[111] Turning back to Morgan, Ferguson asked if instead the failure was because Morgan was willing to degrade jeep tires at the warfront rather than use the power of the War Production Board to compel a gas supplier—currently flaring gas—to deliver to carbon-black plants. Morgan's colleague Twombly agreed with Ferguson that Morgan had the legal power to compel provision of the needed channel black but had failed to exercise it.[112]

Underlying the failure of Morgan to compel gas from Phillips was a controversy between the Rubber Bureau and the Chemicals Division. The Chemicals Division consistently refused to accept figures from the Rubber Bureau on how much channel and gas furnace black was required to manufacture rubber goods for the war effort, even though the Chemicals Division lacked experts on compounding with synthetic rubber. Moreover, the Carbon Black Manufacturers Industry Advisory Committee did not want to approve any other construction of new channel facilities, fearing it would lead to oversupply and lower prices after the war. Colonel Dewey, the rubber director, resigned in September 1944 so that everything would be under one person. The single authority became the chairman of the War Production Board, Nelson Donald.[113] As the shortage crisis continued into 1945, Nelson appointed Michael Deutch as his special assistant and as chairman of the Interagency Committee. Deutch, it turned out, had a pivotal role in the controversy that played out in the final carbon black production meeting of the Truman Committee.

That final meeting on the carbon black shortages was on June 11, 1945. It arose from a call by the head of the Truman Committee, Senator Mead, to find out why—to his surprise and days before their report into carbon black shortages was to be made public—the War Production Board announced on May 30, 1945, that there was no carbon-black shortage and it would lift restrictions on the material on June 14, 1945.[114] The Truman Committee knew that after the May 30 announcement, members of Deutch's own Interagency Committee voted to disband on June 8 because they had been ignored by the War Production Board. The Interagency Committee's last motion, a resolution that was unanimously approved on May 28, was for Deutch to

110. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13878–13879.

111. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13918, 13931, and 13934.

112. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13879.

113. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14074.

114. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14141.

inform the War Production Board that the Interagency Committee was "not in sympathy with lifting the restrictions and asked that such restrictions remain in effect," given that serious shortages remained.[115] Deutch delivered the message to John Collyer, special director of Rubber Programs and the deputy on rubber matters for the War Production Board. However, instead of resulting in restrictions remaining in effect, Deutch was persuaded by Collyer and Morgan, the director of the Chemicals Division, that the supply of carbon black would catch up with demand later in June and the Interagency Committee would no longer be needed.

Mead was incredulous at Deutsch's testimony, noting that Deutch had previously doubted Chemical Division projections and that a drive for surplus carbon black was ongoing. Ferguson said that defective tires were still being sent to the front because there was not enough carbon black being manufactured. Mead asked Deutch to "state for the record that it was your opinion that these few companies were interested in holding down production so they could control the price after the war?"[116] Deutch answered, "Yes, among other things."[117]

Former congressman Judge Frederick Vinson (D-KY) gave the last testimony of the day. Vinson was now the director of War Mobilization and Reconversion. (He was later appointed by President Truman as the secretary of the Treasury and in 1946 as chief justice of the Supreme Court.) Vinson testified that Deutch suggested to him that the Interagency Committee be disbanded on the understanding from the War Production Board that there was an adequate supply of carbon black. Vinson had accepted the recommendation, although without information that the Truman Committee was about to issue a report on the matter, that inferior and fewer tires were being made because of the lack of carbon black, and that the Interagency Committee objected to lifting restrictions and urged that they be continued.[118] Mead admitted that he would have come to the same conclusion as Vinson with the information he received from Deutch, but he remained worried that both he and Vinson were "taken into camp."[119] That the worry did not lead to a reinstatement of carbon black restrictions or a new burst of mobilization was likely due the timing of the hearings, running past the surrender in Europe on May 8, 1945.

The Truman Committee's "Tentative Report on Carbon Black Investigation," dated June 16, 1945, found that the War Production Board's Interagency Carbon Black Committee failed to do its job, even "with full power to act to remove bottlenecks which stand in the way of increased production."[120] It also found that the carbon black deficit in excess of 250,000 tons per annum was attributable in part to the refusal of Phillips to supply natural gas for carbon

115. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14121.

116. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14133.

117. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14133.

118. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14140–14141.

119. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14143. The phrase "taken into camp" means defeated (see "Base-Ball Games: The Champions Taken into Camp by the New-Yorks," *New York Times*, May 23, 1884, 2).

120. US Special Committee Investigating the National Defense Program, "Tentative Report on Carbon Black Investigation," June 16, 1945, 36½–38½, Record Group 46, Box 1047, Archives I, NARA.

black production unless its price demands for gas were met and to alternatively flare it when price demands were not met.[121] It also found Phillips exercised options in contracts to cancel gas supply agreements on days' notice and then asked for an increase in price under a new proposed contract. The report concluded that the "[i]ndustry went on strike, a strike which goes to the very vitals of the entire war program."[122] The conclusion foreshadowed the outcome of a proceeding brought by the Federal Trade Commission on October 28, 1944, against carbon black manufacturers and their export association, alleging violation of the provisions of the Webb-Pomerene Act. The allegation was that the carbon black producers had entered into agreements to limit production and to fix prices in the United States. The decision, issued on June 12, 1949, found agreements in violation of the law.[123]

The responses from the carbon black industry to the Senate's tentative report were critical. A researcher from one of the carbon black firms attributed the crisis to an increased synthetic rubber production schedule of seven-days per week and twenty-four-hours a day.[124] Phillips found no serious issues with the supply of channel black.[125] It emphasized it had not gone on strike but rather had sought approval to build additional manufacturing capacity (about 568,000 tons per year) with its own funds, which was rejected by the federal government but was later permitted to build a plant to manufacture only 100,000 tons per year. Likewise, the response from Thomas Cabot was that Cabot had not gone on strike, had not in any way governed the Chemicals Division, and had been ready and willing to build and operate at cost additional carbon black production facilities since 1942.[126] The major problem with the supply of carbon black during the war was, according to Cabot, that the industry had difficulty buying additional gas at the prices set in prewar times when gas was being vented. The response from United Carbon elaborated on the core issue of natural gas supply pricing mentioned in the Cabot letter.[127]

One of the fundamental differences in the government and industry perspectives was that while the Senate investigation found that natural gas suppliers and carbon black companies acted hand-in-glove to increase natural gas prices and thus the price of carbon black, the industry argued it was because of extension of natural gas pipelines into carbon black producing territories. In the industry narrative, natural gas prices had risen because long-term gas supply agreements began to expire in 1944, with most expiring in 1945 and 1946. Carbon black companies had earlier moved into the Texas Panhandle and entered into long-term natural gas

121. US Special Committee Investigating the National Defense Program, "Tentative Report on Carbon Black Investigation," June 16, 1945, 20, Record Group 46, Box 1047, Archives I, NARA.

122. US Special Committee Investigating the National Defense Program, "Tentative Report on Carbon Black Investigation," June 16, 1945, 7–8, Record Group 46, Box 1047, Archives I, NARA.

123. Investigations and Recommendations under the Export Trade Act, In the Matter of Carbon Black Export Inc., et al., Report of Investigation, Conclusion and Recommendations in re Alleged Violations of the Export Trade Act: https://www.ftc.gov/sites/default/files/documents/commission_decision_volumes/volume-46/vol46pg1245-1345.pdf.

124. Cohan, "Carbon Black in War and Peace," 2080.

125. Letter from R. C. Jopling, vice president, Phillips Petroleum Company to Hon. James M. Mead, July 16, 1945, 1–2, Record Group 46, Box 1046, Archives I, NARA.

126. Thomas D. Cabot, "Statement of Thomas D. Cabot," vice president of Godfrey L. Cabot, Inc., June 28, 1945, 1, Record Group 46, Box 1046, Archives I, NARA.

127. United Carbon Company, "Statement of the United Carbon Company," June 28, 1945, 1. Record Group 46, Box 1046, Archives I, NARA.

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supply agreements. This allowed them to benefit from the availability of surplus natural gas, priced at 1.2 cents per thousand cubic feet. As pipelines were built and the natural gas industry found other customers for their product, Panhandle gas prices rose threefold to pipeline prices. During the war, gas prices were about 3.5 cents per thousand cubic feet.[128] According to a 1947 federal government report, this underlying argument had merit by noting natural gas prices for carbon black production had increased from less than 1 cent per thousand cubic feet in 1939 to an average price of 3.57 cents by 1947.[129]

In late summer and fall 1945, Peter Connolly, the assistant counsel to the Truman Committee, prepared the conclusions from the investigation.[130] The *Fifth Annual Report* of the Truman Committee, dated September 3, 1946, concluded that the shortages in the carbon black program in 1945 occurred because the Office of War Mobilization "failed to act as a directing and managing organization," which in turn led to "misunderstandings, ineffective programs, and delays."[131] This failure to act included the Interagency Committee, which "never succeeded in controlling the carbon black program."[132]

Notwithstanding these failures in mobilization, the wartime increases in gas furnace reactor capacity and invention of oil furnace reactors led to postwar growth. By the end of 1946, carbon black production exceeded 600,000 tons, doubling since 1941. In 1950, for the first time, annual furnace production was greater than channel production. Three years later, in 1953, total production rose to over 800,000 tons, with channel production making up only about 28 percent of total production.[133] By 1955 more than 50 percent of production was from oil feedstocks.[134] This trend was due to rising natural gas prices and wartime innovations to conserve natural gas supply by reinjecting it back into underground reservoirs.[135] As long-term gas supply contracts expired, new contracts were presented with higher prices set in the context of not stranded gas assets but markets made by new gas pipelines. The rubber industry also increasingly preferred furnace black over channel black for mixing with synthetic rubber. This was true especially for oil furnace black because it could produce more grades for tire production; had better abrasion resistance in treads; and, by 1955, had more than double the yield of gas furnace black.

Conclusions

There are similarities in the role played by the War Production Board with synthetic rubber and carbon mobilization. The synthetic rubber program was a success because the federal

128. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 14062.

129. Lott, Backus, and Tyler, "Carbon Black" (1945), 195.

130. Memorandum from Peter J. Connolly to Rudolph Halley, August 18, 1945, Record Group 46, Box 1047, Archives I, NARA; Memorandum from Peter J. Connolly to Rudolph Halley, September 10, 1945, Record Group 46, Box 1047, Archives I, NARA.

131. US Senate Special Committee Investigating the National Defense Program, *Fifth Annual Report*, 10.

132. US Senate Special Committee Investigating the National Defense Program, *Fifth Annual Report*, 290.

133. Colby, Barton, and Oppegard, "Carbon Black" (1953), 303.

134. Colby and Mahoney, "Carbon Black" (1955), 268.

135. US Senate Special Committee Investigating the National Defense Program, *Part 29, Carbon Black*, 13855.

government financed mass production. Likewise, the carbon black program was successful because the War Production Board used construction and procurement strategies to increase production in World War II (although not without emergency measures when the rubber industry moved to round-the-clock operations in 1945). These strategies made it possible for the industry to transition to gas furnace production: gas furnace made up 17 percent of total production in 1941 and was nearing 50 percent by 1944.

Government-sponsored collaborative research was plagued by inadequate scientific and technical advice and poor government leadership, yet it still realized some tangible wartime success. As noted, efforts to organize technical cooperation among carbon black producers in advance of the oil furnace process pilot projects were unsuccessful, and an industry visit to a leading channel plant was canceled. While the firms' unwillingness to share trade secrets with competitors is understandable, especially given industry expectations about increasing natural gas prices and postwar markets, there was a lost opportunity to accelerate development of the oil furnace process within individual firms. The first two oil furnace plants (owned by Phillips) financed by the Construction Bureau were only approved in March and May 1944, more than a year after Phillips had filed the patent on the reactor technology and after Phillips had constructed its own oil furnace plant.

To the positive role of government in technological innovation, the cooperative research program between the rubber and carbon black industries, sponsored by the War Production Board, was instrumental in accelerating successful manufacturing of GR-S synthetic rubber goods during the war. The program created interindustry standard-setting for individual industrial research laboratories to develop new production processes and grades of gas and oil furnace black. Underscoring the pioneering nature of this program is that the carbon black industry only developed uniform chemical testing procedures in 1952. In the case of the oil furnace process, these wartime discoveries led to contemporary carbon black manufacturing.

Prewar science and technology were also instrumental in synthetic rubber and carbon black. In the case of synthetic rubber, the fundamental research was conducted by I. G. Farben. For carbon black, firm-based development of the gas furnace process from the early 1920s laid the technological foundation for meeting wartime production goals. Research and development of the oil furnace process, beginning in 1937, provided the dominant technological platform in terms of tons produced from 1955 to the present.

The carbon black industrial R&D, War Production Board-sponsored cooperative research, standard-setting within the rubber and carbon black industries, and use of federal government contracts to finance plant construction were all part of a broader industry strategy to transition away from an eighty-year-old business model that used low efficiency plants to extract, ship, and sell a solid fossil fuel product manufactured from stranded natural gas assets. In this transition, the carbon black industry followed rubber manufacturers that had, since 1900, increasingly emphasized investments in R&D and technical innovations to increase productivity.[136] The move to high-efficiency carbon production technology fits within Schmookler's framework in its response to expanding consumer demand.[137] As natural gas in carbon producing areas flowed into distant markets and the frontier of cheap natural gas disappeared,

136. Yacob, "Model of Welfare Capitalism?" 167.

137. Nye, *Consuming Power.*

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farsighted carbon black producers like Phillips and Cabot adapted to a high-efficiency business model, anchoring their value proposition in reduced production costs through technological innovation.

In contrast to the aluminum and magnesium cases (of federal government purchase of material from Alcoa and Dow, respectively), the War Production Board did not have procurement alternatives that avoided the carbon black industry's leading firm. Phillips was already integrated with the other large producers, supplying them with gas and using them as distributors of Phillips's own carbon black. This oligopolistic market structure reduced the leverage of the War Production Board. To accelerate the transition to high-efficiency plants, the carbon black industry—through Starkie and War Production Board committees made up of its industry members—influenced the Chemicals Division to urge smaller amounts of lower-priced channel black and greater amounts of higher-priced furnace black. Through the federal government's standard-setting program, procurement, and sponsored construction contracts, the carbon black industry applied its long-term industrial research discoveries to transform its business model and invent the technology for high-efficiency furnace production in the 1940s. This process is now more than eighty years in continuous operation.

In summary, the industry dominated the government–business relations in World War II carbon black mobilization. The War Production Board did not effectively resolve or even comprehensively report on disputes among synthetic rubber and carbon black industry factions within its operations. It also did not resist supplier control over product prices and specifications and industry approval for government-financed plant construction projects. Even the Truman Committee, with the power of investigations and hearings, failed to name names and articulate blame in its public report, other than making broad statements about mismanagement. Senator Mead was right to worry that he and Vinson had been taken into camp.

The changes in carbon black production are consistent with Gordon's production miracles from 1941 to 1945 and diverge from the changes occurring in other chemical and petroleum industries as reported by Field.[138] Although there were technical advances in gas furnace reactors and processes in the 1920s and 1930s, their scale-up occurred during wartime, not the Great Depression. Consistent with Gordon and Gross and Sampat, the wartime development of oil furnace reactors and processes, incentivized by higher furnace prices from the War Production Board, provided the technological foundation for production yield increases from about 7 percent in 1945 to nearly 70 percent by 1974.[139] It was this technology that was on the newly built roads and underneath the expanded car and truck production that drove postwar US consumption and economic expansion. To contribute to the Fields–Gordon debate, future research should examine the unique characteristics of other ancillary industries to determine whether they saw similar gains in efficiency and output through wartime mobilization and innovation.

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138. Gordon, *Rise and Fall of American Growth*; Field, "Impact of the Second World War."
139. Gordon, *Rise and Fall of American Growth*; Gross and Sampat, *Inventing the Endless Frontier.*

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