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THE IMPACT OF WORLD WAR II ON THE GROWTH OF U.S. POTENTIAL OUTPUT

by

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ABSTRACT

Robert Gordon (2016) has argued that economic mobilization between 1942 and 1945 laid the supply foundations for output and productivity growth after the war. Such claims have formed the basis of the conventional wisdom for decades. This paper argues, in contrast, that the extraordinary mass production of ships, aircraft, and other munitions during the Second World War had little relevance for the postwar period because the wartime output mix and implicit factor prices were unique to that period, never to be repeated. Measuring between 1941 and 1948, total factor productivity within manufacturing actually declined. The impact of World War II on the growth of US potential output following the war was, on balance, almost certainly negative. (O47, O51, N12)

Robert Gordon's The Rise and Fall of American Growth (2016) brought to a popular audience as well as many economists an interpretation of the broad contours of US economic growth since 1870. In this book Gordon considered the evolution of productivity, consumption, and more generally the standard of living in the United States from the end of the Civil War to the present day. Although the work is determinedly historical – sixteen of eighteen chapters focus principally on the past -- it was the pessimistic forecast for the future developed in previous working papers and summarized in chapters 17 and 18 that generated the lion's share of critical discussion and commentary. The debate featured dueling TED talks from Gordon on the one hand and Eric Brynjolfsson and Andrew McAfee on the other (both from 2013), as well as optimist rebuttals to Gordon from his colleague Joel Mokyr (2016), Deirdre McCloskey (2016), and others.

The historical sections – the bulk of the book – received somewhat less critical scrutiny. One aspect of the narrative, Gordon's exuberantly optimistic interpretation of the economic impact of the Second World War, particularly its effect on US aggregate supply, is a focus of this paper. The question is critical not only for our understanding of mid-twentieth century U.S. economic history, but also because of its relevance for a broader debate about the impact of war and military spending on technological and economic progress. Economists and historians have, on balance, been remarkably sanguine about the beneficial economic effects of war and economic mobilization, both in closing output gaps and in accelerating the growth of potential output. Gordon's is the latest instantiation of this enthusiasm.

Examples of such enthusiasm have been widespread. Three quarters of a century ago, . Louis M. Hacker (1940), speaking of the effect of the Napoleonic Wars on England and of that of the Civil War on the United States, opined that "As far as capitalism has been concerned, modern war (while it lasts) has been an unmixed blessing" (p. 250). He waxed particularly enthusiastically about the propulsive impact of the conflict over slavery in the United States: "Under the leadership of the new and vital force released by the Civil War and Reconstruction measures, American industry strode ahead on seven-league boots" (p. 401), and "…railroading, like industrial production, was … transformed in the fires of the Civil War" (p. 227). Although his analysis was eventually criticized by new economic historians (see, e.g., Goldin and Lewis, 1975), his sentiments about the longer run supply side effects of war continue to have broad resonance, particularly as they apply to the Second World War.

William Baumol (1986) took World War II's contribution to higher productivity growth during and after the war as established fact: "It is noteworthy that the great leap above historical US productivity growth in the war and early postwar years were just about as great as the previous shortfalls during the Great Depression" (1986, pp. 1081-82). Vernon Ruttan posed a provocative question in the title of his 2006 book, "Is War Necessary for Economic Growth?" He answered the question affirmatively: It is difficult to overemphasize the importance of the historical role that military procurement has played in the process of technology development…" (2006, p. 3).[1] Without war, he suggested the R and D spending necessary to develop new general purpose technologies would simply not be forthcoming. The views expressed by these authors reflected a shared optimism about the long run economic benefits of war and military spending, and are particularly influential insofar as they apply to the United States experience during the Second World War.

[1] He went on to argue that "military and defense related R&D and procurement has been a major source of technology development across a broad spectrum of industries that account for an important share of U.S. industrial production" (p. 5), emphasizing computers and the internet, but passing lightly over the contrasting histories of electricity and the internal combustion engine.

Long Run Productivity Trends in the US Economy

Gordon originally settled on One Big Wave as his way of calling attention to the strong TFP growth that characterized the second and third quarters of the twentieth century in the United States. As a metaphor about levels, this never quite fit, since when a wave is past it leaves the water at its original level, whereas this wave left TFP levels and our standard of living permanently higher. The metaphor worked somewhat better when applied to rates of growth rather than levels, although levels are what come most readily to mind. In any case, in The Rise and Fall of American Growth Gordon abandoned this catchphrase and adopted instead that of a Great Leap Forward. The idea of applying this language to TFP growth in the 1930s originated with Field (2011).

Gordon cited Baumol (the quote referenced above) as evidence that the idea of a 'great leap' was current in the literature a quarter century before Field published (Gordon, 2016, pp. 706-07). But Baumol, as we have seen, used the words to apply to a period after 1941, accepting the then conventional wisdom that productivity advance was below trend between 1929 and 1941. His view, roughly the opposite of what Field argued, epitomized what had for decades been the conventional view of the Depression and the war. Whereas Gordon accepted Field's revisionism regarding (at least moderate) productivity advance between 1929 and 1941, he persisted in retaining (but repackaging as new) the "economic miracle" interpretation of the supply side effects of the war, arguing that TFP growth across the war years greatly exceeded that during the Depression.

He announced this view at the start of his chapter 16: "The most novel aspect of this chapter is its assertion that World War II itself was perhaps the most important contributor to the Great Leap". That statement included the qualifier 'perhaps', but as Gordon warmed to his argument, he abandoned hedging: "In fact this chapter will argue that the case is "overwhelming for the "economic miracle" interpretation of World War II along *every conceivable dimension*…" (p. 537, my italics). Gordon's passionate endorsement of the transformative effects of the Second World War matched the enthusiasm with which Hacker, three quarters of a century earlier, had embraced the U.S. Civil War.

Gordon's claims, it should be evident, are not novel. There is little dispute that World War II confirmed the fundamental Keynesian prediction that massive fiscal stimulus combined with expansionary monetary policy could bring a depressed economy to full employment within a very short time. It has also been commonly argued, as had Baumol, that the war was associated with a permanent boost on the supply side. Evaluating that claim is a main focus of this paper. One of its contributions is to show that, measuring between 1941 and 1948, total factor productivity within manufacturing actually declined (please see the Appendix). Why? The learning by doing and process innovation resulting from the mass production of military hardware during the war turn out to have been largely irrelevant given the product mix and factor prices prevailing after the war. And the government funded expansion of war related plant and equipment to which Gordon has devoted much attention over his career (Gordon, 1969),[2] had much weaker long run effects on potential output than did the streets and highways, bridge, tunnel, and hydro construction of the 1929-41 period (Field, 2003, 2011).

Gordon suggested that the 'economic miracle' of the second World War propelled total factor productivity to a permanently higher level, and was largely responsible for setting the stage for the golden age of labor productivity growth (1948-73). This was his explanation: "The

[2] Gordon referred to these as GOPO (government owned, privately operated) plants. The more common acronym is GOCO (government owned, contractor operated).

most obvious reasons why productivity remained high after the war was that *technological progress does not regress.* People do not forget. Once progress is made… it is permanent". After the war, "As they struggled to fill orders that seemed almost infinite, they adopted all that they had learned about efficient production in the high pressure economy of World War II" (p. 550).

Gordon repeated the oft cited examples of learning by doing building airframes and Liberty ships, and then argued that "the shipyard example can be generalized to the entire manufacturing sector" (p. 549), and that "Every part of the postwar manufacturing sector had been deeply involved in making military equipment or its components, and the lessons learned from the war translated into permanent efficiency gains after the war" (p. 550).

The involvement of US manufacturing firms in wartime production was indeed broad. And the effects of learning by doing on productivity in shipbuilding and aircraft are well known to economists (Arrow, 1962; Alchian 1963). What is not clearly established are the effects of wartime production experience on levels and rates of TFP growth in the postwar period. These effects should have been most apparent within manufacturing. The relevant comparison years are 1941 and 1948. The former is the last year before full scale war mobilization. Although Lend-Lease and some rearmament had begun, less than 5 percent of cumulative real military spending between 1940 and 1945 inclusive had taken place at the time of Pearl Harbor (Field, 2011, p. 85). By 1948 demobilization was largely complete and the economy, now on a civilian footing, was close to potential, as evidenced by the low 3.8 percent unemployment rate. As table 1 shows (see Appendix), TFP growth in manufacturing across those years was negative.

Productivity advance in the private nonfarm economy between 1941 and 1948 was, overall, positive. But the main contributors to TFP growth were sectors other than manufacturing, in particular wholesale and retail distribution, railroad transportation, and electric and gas utilities (tables 2, 3 and 5 below; see Appendix). These were sectors, in contrast to manufacturing, that the war starved of capital. War did inspire process innovations. But these had more persisting benefits in sectors disadvantaged by war mobilization, not those favored with government funded plant and equipment, and featured in learning by doing narratives and stories about production miracles. Why? Unfavored sectors (unlike manufacturing) were less likely to experience the wrenching changes in product mix and share of overall output that came with demobilization, and thus process improvements were more likely to be of persisting value in the postwar economy. This suggests that we might be well served, in thinking about contributions to long run growth, in focusing more attention on learning by doing *without*.

Wherever they occurred in favored or unfavored sectors innovations were often in response to and especially suited to a highly unusual set of input availabilities and implicit factor prices, conditions that would disappear with the end of the war. Construction firms, for example, faced with shortages of structural steel, developed kiln dried wood forms called, due to their shape, thunderbirds. These served as effective roof bearing substitutes in many of the one-story factory buildings hastily erected by the federal government (Walton, 1956, p. 214). This innovation, however, was a response to a materials shortage that would not persist. It was of little relevance in the postwar period.

What of the effects of learning by doing? The argument that World War II production experience had positive persisting effects on aggregate supply almost always begins with the Liberty ships and goes on to cite examples of the inverse relationship between cumulated output and the unit labor requirements for B-24s, C-47s, or Oerlikon antiaircraft guns.[3] These gains, although they require some qualifying observervations, were nonetheless real. But they did not generalize to the rest of the economy, and did little to boost either civilian or military production capability after it. The manufacture of most of these products ceased by V-J day. In contrast to what was true during the war, postwar military hardware had limited production runs and much higher costs per unit.

It is doubtful that the wartime diversion of resources to military production advanced the production of consumer durables after the war. Then, as now, the most important of these were automobiles. In 1939, the car industry accounted for 18 percent of the steel, 80 percent of the rubber, 34 percent of the lead, and 10-14 percent of the copper, tin, and aluminum consumed in the US economy. Output and sales of passenger vehicles rose rapidly in 1940 and 1941, as growing defense spending and foreign orders primed the pump of an economy finally emerging from a decade of depression. Well in advance of Pearl Harbor, government economists concluded that trying to satisfy growing demands for both consumer durables and military hardware would exacerbate developing shortages in steel, machine tools, and other key materials.

If war was imminent, the economy had to cut back on metal using consumer durables, particularly automobiles. Industry leaders resisted curtailment, arguing (wrongly) that only a small part of its plant and equipment could be converted to military production. They were joined by officials in the Office of Production Management, which, echoing other industry fears, wanted curtailment to be done gradually. The concern, after a decade of Depression, was to

[3] Roosevelt's "Must List" of January 6, 1942 announced unit production targets for 1942 and 1943 in four categories: Planes, Ships, Anti-Aircraft Guns, and Merchant Ships (Edelstein, 2001, p. 60, citing Smith, 1959, p. 141). Guns and (military) ships were the biggest ticket hardware items in the US war effort (Smith, 1959, p. 7).

avoid unemployment or idle factories that might arise in any gap between curtailment and the anticipated ramp up in military orders. The President, government economists, and other New Dealers pushed for speedier reductions in civilian production (Koistinen, 2004, pp. 130-132).

Modest curtailment began prior to Pearl Harbor, pursuant to an August 21, 1941 agreement. The commencement of hostilities greatly accelerated the process. The government quickly prohibited, effective January 1, 1942, all sales of as well as the delivery of previously ordered cars, trucks, and parts. Effective February 22, 1942, the production of all US passenger vehicles, commercial trucks, and auto parts ceased. Half-finished assemblies, along with many specialized tools and dies, were sent to salvage to be melted down and recycled. Car dealers retained an inventory of 520,000 1942 model vehicles produced but not yet sold; these with a special permit could purchase one during the war. Design work on new models ceased completely for thirty months, resuming again in the fall of 1944, subject to the restriction that it not interfere with still ongoing war work. Production of new vehicles recommenced in October of 1945.[4]

Refrigerator and appliance production, including washing machines, cookstoves, metal office furniture, and vacuum cleaners likewise ceased during the war. Commercial television had been introduced at the 1939 New York World's Fair, but the war delayed large scale production and take up for at least six years. Production of TV sets was completely prohibited between April of 1942 and August of 1945. Learning by doing in each of these commodity classes ceased. Contrary to what Gordon suggests, it is unlikely that experience gained building

[4] The situation with respect to truck technology is somewhat more nuanced. Between 1942 and 1945 the US produced for the military close to 2.4 million light, medium, light-heavy, and heavy-heavy trucks (Smith, 1959, p. 9).

B-17s or Sherman tanks compensated by generating major beneficial spillovers in civilian production after the war.

Undoubtedly the war propelled forward many military technologies, including the beginnings of the move from piston driven to jet aircraft, the supplanting of the battleship by the aircraft carrier, the development of rocketry, and of course the atomic bomb. Nuclear power, of course, did have civilian applications, but its benefits in the postwar economy were mixed: the technology never delivered on its early promise of electricity too cheap to meter. Even in aviation, the impact on product innovation is uncertain. Davis and Stammers, based on the English experience, suggest that advances in gas turbine technology may have been one of the few areas where the war advanced a useful postwar technology (1975, p. 515). Even in this instance, on the other hand, one can note that aircraft design was advancing rapidly during the 1930s, and jet aircraft might well have arrived as quickly in the absence of the conflict. The B-29, the one combat aircraft that had not yet been flown at the time the US entered the war, and the single most expensive weapons project in the Second World War (more than $3 billion as compared with $2 billion for the Manhattan project), was entirely pressurized and boasted a state of the art fire control system. Most significantly, it advanced monocoque technique – the external skin of the plane contributed to its structural integrity. But the design concept went back decades—and the last generation of bombers with propellers likely would have had it with or without the war. Moreover, as was the case for every other aircraft described here, the design work on the B-29 was finished prior to Pearl Harbor, with the first orders placed in May of 1941.

The idea that learning by doing during the war laid the foundation for postwar production success is questionable from a number of perspectives. A stronger case can be made that the production achievement of the Second World War reflected the application of mass production techniques learned building automobiles and refrigerators in the 1920s and 1930s to the production of aircraft and other military goods designed, in most cases, prior to Pearl Harbor.

Influences on Potential Output

How might the Second World War have had a large and persisting positive impact on potential output in the United States? It might have done so by sweeping away retardative institutional obstacles through a permanent change in the philosophy or instrumentalities of government. It might have done so by destroying infrastructure, plant or equipment, allowing it to be replaced or rebuilt along more efficient lines. These two varieties of 'prairie fire' explanation suggest that in spite of, indeed, because of its destructive power, war burns away historical underbrush, clearing paths for modern, more dynamic growth.[5]

The Second World War did leave significant institutional, normative, and economic legacies for the United States. It solidified a compression of wages that endured for three decades. Experience with high tax rates and the introduction of withholding gave the federal government expanded fiscal capacity. Controls on wages led inadvertently to the U.S. system of largely employer provided health care insurance. And the war presaged, after a brief lull, permanently higher levels of military spending, which had persisting regional economic effects (Wright, 2017). The war was not, however, associated with a political revolution or fundamental changes in the instrumentalities and philosophy of government. Nor, aside from the destruction on the island of Oahu and possibly the wear and tear on plant and equipment resulting from running double and triple shifts did the war destroy infrastructure within the continental United States.

[5] These ideas build on and takes strength from older and highly evocative tradition that saw war as rejuvenative. Theodore Roosevelt was a notable exponent of this view.

The argument must therefore turn on something other than expansive "prairie fire" reasoning: the putative longer run effects on total factor productivity growth and/or the growth of hours and physical capital services. In other words, it must turn on more mundane growth accounting explanations.[6] The prairie fire analogy may be relevant for other countries in other historical instances, but not, by and large, for the United States in World War II.

The Macro Evidence on Total Factor Productivity

Gordon's book contains many useful and informative charts and figures. His figure 16-5 is an exception in this sense. Although it appropriately highlighted the generally strong TFP growth between 1920 and 1970, as compared with the decades prior to and following these years, its identification of the 1940s as the locus of peak TFP growth is problematic. According to this figure, TFP growth in the 1940s was almost twice as high as during the 1930s: 3.4 vs 1.8 percent per year, which appears largely to confirm Baumol's generalization.

Gordon provides only partial documentation of his sources and methods, which creates challenges in exploring the figure's underpinnings. My approach will be to ask whether calculations of aggregate economy TFP growth measuring to and from 1940 can plausibly be used as estimates of the growth rates between peacetime business cycle peaks across the Depression years and across the war years.

Gordon, as well as Kendrick (1961), Abramovitz and David (2000), and Field (2003, 2011) all operate within a longstanding NBER tradition which emphasizes the necessity, to the extent possible, of estimating trend in macroeconomic series by measuring between peaks. There are strong cyclical effects on productivity, which is why it is so important to measure TFP growth

[6] 'Prairie fire' effects might of course, ultimately be reflected in any of the components of a growth accounting exercise.

rates between years where the economy is at or close to potential. Figure 16-5 violated this principle by simply reporting decadal growth rates of TFP. 1940 was considerably below potential: Lebergott unemployment was close to 15 percent. 1941 is the closest we can get to potential prior to the distortions of the economy associated with full scale war mobilization. For the postwar peak 1948 is preferable to 1950 – since the unemployment rate was lower in 1948 than in 1950. And 1929 is preferable to Gordon's sometime preference for 1928; since unemployment was lower in 1929 in the absence of any evidence of goods and services price inflation. Either should be preferred to 1930, which had an 8.7 percent unemployment rate.

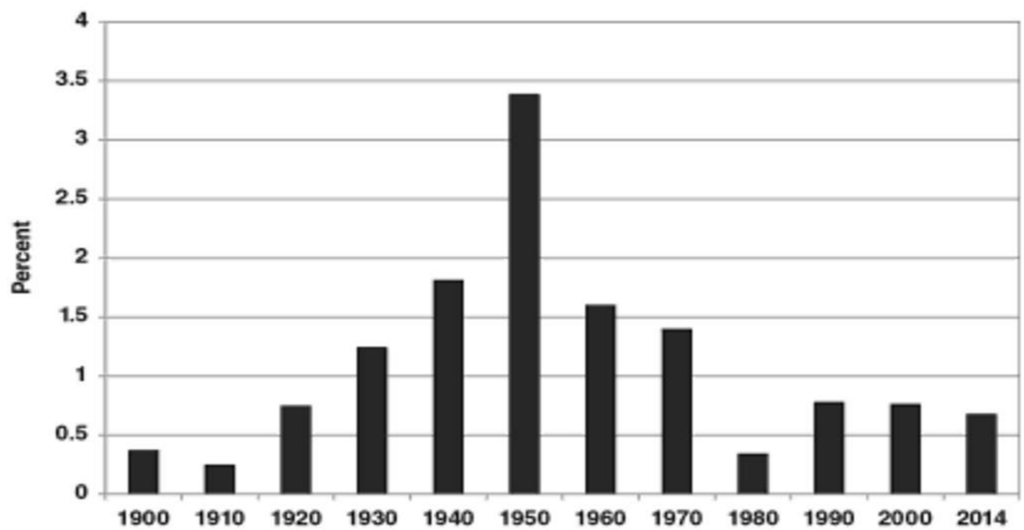

Figure 16–5. 10-Year Average Annual Growth in Total Factor Productivity, 1900–2014

Note: The average annual growth rate is over the ten years prior to year shown. The bar labelled 2014 shows the average annual growth rate for 2001–14.

Source: Gordon (2016, p. 547).

But the choices of 1948 vs. 1950, or 1928 or 1929 in lieu of 1930 have minor implications compared to the use of 1940 as a benchmark. Because of the procyclicality of TFP, measured productivity levels were substantially lower in 1940 than in 1941, reducing a calculated growth rate to 1940 and increasing a calculated growth rate from 1940, as compared with calculations that measure to and from 1941.

Over his career Gordon has made various adjustments to labor and capital input that changed measured TFP growth rates between benchmark years. He originally identified 1928-50 as evidencing peak TFP growth, and it is this chronology that he featured in several editions of his macroeconomics textbook, beginning in 1993 and extending through the eighth edition in 2000. Sometime around 2000 he made a new set of adjustments that tipped the balance towards 1950-64.

Field (2003; 2011, pp. 27-30) expressed skepticism about the net effect of these adjustments and the then newfound enthusiasm for 1950-64. In The Rise and Fall of American Growth, Gordon shifted back to locating his great leap in the second quarter of the century. The remaining issues dividing Gordon and Field are *when* during the second quarter of the century peak advance occurred and whether wartime production experience had persisting beneficial effects on TFP growth in the postwar period. Gordon quoted this pessimistic evaluation by Abramovitz and David: “the war … imposed restrictions on civilian investment, caused a serious reduction in private capital accumulation and retarded normal productivity growth.” (p. 547). Gordon stated that because of his ‘new’ interpretation, that view was “called into question.”[7]

[7] While endorsing for the most part Abramovitz/David’s conclusions about the war, Field took issue with their broader narrative of the twentieth century as reflecting a dependence on knowledge based growth that differed fundamentally from what had been true in the nineteenth. Field argued that Abramovitz/David generalized from the high TFP growth of the first half of the twentieth century, a generalization which the data from the second half did not support. In particular, with data on the entire twentieth century now available, he pointed out that TFP growth in the last third of the twentieth century was lower than it had been during the comparable period in the nineteenth.

Gordon's estimates of TFP growth in the 1930s and 1940s

Can Gordon's estimate of TFP growth in the decade of the 1940s proxy for a measure from the year of the lowest output gap prior to mobilization (1941) to the business cycle peak immediately following demobilization (1948)? Between 1940 and 1950 real output calculated using chained index methods grew at 5.6 percent per year (Bureau of Economic Analysis, NIPA Table 1.1.6). Gordon has TFP growth between 1940 and 1950 at about 3.4 percent per year (figure 16-5). That leaves 2.2 percent per year for the combined contribution to growth of increases in labor and capital input. But we were well below potential in 1940. We do not want to measure from trough to peak.

Real output growth between 1941 and 1948, again from the BEA, was 4.3 percent per year, which means that, if Gordon's 1940-50 TFP growth rate of 3.4 percent adequately proxies its growth rate between 1941 and 1948, only .9 percent per year is left for the combined contribution to growth of increases in capital and labor input. That is too low, given what we know about the growth of these inputs during those seven years.

Kendrick (1961, Table A-XXII) shows private domestic economy labor input growing at 1.71 percent per year between 1941 and 1948.[8] The BEA's Fixed Asset Table 1.2, line 3 shows private sector fixed assets growing at 1.58 percent per year over the same period. Weighting labor input growth by .7 and capital input growth by .3, we have growth of inputs conventionally measured at about 1.67 percent per year. TFP could not have been growing at 3.4 percent per year between 1941 and 1948, simply because 3.4 + 1.67 = 5.07, whereas real output growth over that period was 4.3 percent per year. TFP growth, as a residual, is 'squeezed' between the

[8] Kendrick 'quality adjusted' series weighted different categories of labor by their respective wage rates. Unweighted manhours grew at .56 percent per year.

output growth rate (4.3 percent per year) and the combined input growth rate (1.67 percent per year). The highest it could have been growing between those years was 2.63 percent annually.

But that is before a cyclical adjustment for the level of TFP in 1941. Unemployment was still just under 10 percent for that year. Because of TFP procyclicality, a cyclical adjustment will raise the TFP estimated growth rate for 1929-41 and lower it for 1941-48. Field (2010) estimated, based on more than a century of data, that each one percentage point reduction in the unemployment rate adds roughly 1 percentage point to the growth rate of economy-wide TFP, above and beyond trend (Field's law). A cyclical adjustment based on this regularity adds close to a half a percentage point to the 1929-41 growth rate of TFP, and subtracts even more from the 1941-48 rate (see below).

Now consider productivity growth across the Depression years. Again, it makes a big difference whether we measure to and from 1941 as opposed to 1940. Measured using chained index methods, real output growth between 1929 and 1940 is 1.64 percent per year; between 1929 and 1941 it is 2.87 percent per year. Gordon has TFP growth for the 1930s at about 1.8 percent per year. Could that plausibly proxy for the 1929-41 rate? Between 1929 and 1941, private sector quality adjusted labor input was basically unchanged, declining at .06 percent per years (hours decreased at -.26 percent per year (Kendrick, 1961, table XXII)). Private fixed assets increased at .22 percent per year (BEA, Fixed Asset Table 1.2, line 3). Weighting capital growth by .3 and labor growth by .7 we have inputs conventionally measured increasing hardly at all (.07 percent a year). Combining this with the BEA data indicating output increasing at 2.87 percent per year, we have TFP between 1929 and 1941 growing at about 2.8 percent per year. This is already a percentage point higher than suggested by Gordon's table 16.5. And it is before a cyclical adjustment.

Based on Field's law, we can ask what the level of 1941 TFP would have been had unemployment been 3.8 percent (as in 1948) as opposed to the actual 9.9 percent. The 1941 level would have been about 6 percent higher, which adds approximately .5 log percentage points to a TFP growth rate calculated over the period 1929 – 1941 (2.8 +.49 = 3.29). At the same time, using the adjusted 1941 level and calculating growth to 1948, we have TFP growth across the war years of 1.80 percent.[9] Gordon's table 16.5 suggests TFP growth in the 1940s almost twice as high as during the 1930s: 3.4 vs 1.8 percent per year. My calculations suggest that the respective annual growth rates: 1.80 (1941-48) vs 3.29 (1929-41) were almost exactly the reverse.

These numbers do not take into account any of Gordon's proposed capital service flow adjustments. In The Rise and Fall of American Growth, Gordon makes several adjustments to capital input, including adding government capital,[10] making an adjustment for variable depreciation rates, and reweighting the equipment and structures capital stocks as proxies for service flow. The rationale is that equipment has a higher user cost of capital because a higher proportion of it depreciates each year. The adjusted series allocates a higher fraction of a higher log point increase between 1928 and 1950 to the 1928-41 period, and a lower fraction to 1941-50. This will reduce estimates of TFP increases for the entire economy in the former period by more than it does in the latter period. Would it be enough to make a difference, and lead to the conclusion that such growth was higher across the war years as opposed to across the Depression years?

[9] Adding 6 percent to the 1941 TFP level reduces the 1941-48 growth rate by .83 log percentage points.
[10] Gordon includes not just government capital clearly complementary to private sector capital (e.g. streets, highways, bridges, tunnels, and sewers) but also military structures (but not equipment). Each of these adjustments raises conceptual and other issues that deserve more extended discussion but are beyond the scope of this paper.

Replacing Gordon's "official BEA capital" with his adjusted capital (which includes all three of the above adjustments) adds 20.9 log points to 1941 capital levels as compared with 1928 (Gordon, 2016, table A-2, line 5, p. 666). This implies an upward adjustment of 1.6 percent per year (20.9/13) in the continuously compounded growth rate of capital between 1928 and 1941. Assuming a capital share of .3, this adjustment would chop .48 percentage points off my estimate of 3.29 percent per year between 1929 and 1941, bringing it down to 2.81.

The adjustments also raise capital growth rates for the period 1941 to 1950, but not by nearly as much. Official BEA capital increases 18 log points, whereas the adjusted series goes up 21.2 points, a 3.2 log point difference, which, dividing by 9, would add .36 percentage points per year to the continuously compounded growth rate of capital between 1941 and 1950. Again using .3 for capital's share, and assuming Gordon's revised capital growth rate between 1941 and 1950 would look similar to that between 1941 and 1948, this would reduce my estimate of TFP growth between 1941 and 1948 by .11 percentage points, bringing it down from 1.80 percent estimate per year to 1.69, as compared with 2.81 across the Depression years (1929-41). Whatever their merits, these adjustments would not reverse the conclusion that economy-wide TFP growth was substantially higher across the 1929-41 period than it was between 1941-48 or 1941-50.

These are not just games with numbers. They can fundamentally influence our interpretation of the economic consequences of the war. Gordon's figure 16.5 is the statistical underpinning of his interpretation of the Second World War. It is deeply misleading insofar as it suggests a very high trend growth rate of TFP across the war years. Mobilization introduced temporary and quite wrenching changes in the economy's product mix and in the explicit and implicit factor prices producers faced. From the standpoint of aggregate supply, it was highly disruptive. It produced technological advance in the form of both process innovation and learning by doing, but much of this was irrelevant in the postwar period.

In a passage close to the end of chapter 16, Gordon perhaps inadvertently acknowledges how much his procedures in figure 16-5 have distorted and diminished the contribution of the 1930s: “This chapter has sought to quantify and then determine the causes of the great leap of labor productivity and TFP growth between the late 1920s and early 1950s, thus accounting for how TFP growth in the decades of 1930-40 and 1940-50 *outpaced any others in American history*” (2016, p. 563, my italics). Figure 16-5 shows TFP growth in the 1930s not only roughly half what it was in the 1940s but also lower than it apparently was in the decades of the 1950s and the 1960s, which appears to contradict the statement just made.

Learning by Doing

Is the finding of negative TFP growth within manufacturing, and slower aggregate productivity advance across the war years compared with the Depression period consistent with other data? The intent here is to probe more deeply into the plausibility of the conventional argument (which Gordon resurrected as new) that the success of military production during the war laid the foundations on the supply side for postwar prosperity. It is worth repeating Gordon’s case for this: “The most obvious reasons why productivity remained high after the war was that *technological progress does not* regress. People do not forget. Once progress is made… it is permanent” …After the war, “As they struggled to fill orders that seemed almost infinite, they adopted all that they had learned about efficient production in the high-pressure economy of World War II” (p. 550).

To evaluate this claim we must identify where the technological progress is alleged to have been most concentrated, and consider whether it is likely to have benefited production in the postwar period. The most frequently cited examples of such success involve stories of the declining cost per unit of ships, planes, tanks, and other ordnance. The 'miraculous' effects of learning by doing during the war are well known to economists, largely as the result of Kenneth Arrow's 1962 article in the Review of Economic Studies and Armen Alchian's 1963 article in Econometrica. Citing work by Wright, Verdoorn, and Lundberg, Arrow noted that it was well established that the number of labor hours required to complete an airframe dropped predictably with the number of previously completed airframes, that the Horndal iron works in Sweden had experienced a 2 percent annual increase in labor productivity over a fifteen-year period in the absence of any new physical investment. He then explored the theoretical implications of these observations Alchian also took the effects of learning by doing as well established, and explored how reliable were statistically estimated learning parameters in airframe production in predicting the decline in labor requirements per pound of aircraft as a function of cumulated output.

The labor productivity gains experienced in the manufacture of military goods – not just airframes but also Liberty Ships, Oerlikon antiaircraft guns, and other ordnance, were certainly important for the war effort. In some cases, as in the substitution of welding for riveting in ship construction, there were the result of process innovations. But the gains derived largely from improvements in the organization and coordination of production as experience grew. Let's consider the possible effects of learning by doing in aircraft production both during the war and thereafter. Learning by doing might generate three types of advance that would show up in a residual measuring 'technological' progress in manufacturing between 1941 and 1948: 1) gains in producing a particular type or model of aircraft; 2) broader gains in the understanding of how to produce large quantities of aircraft within a very short time frame, and 3) gains that might have applicability to manufacturing more generally.

It is uncontroversial that gains in category 1 were large. The United States produced approximately 276,000 aircraft between 1942 and 1945, and over 300,000 between 1940 and 1945. This achievement cost roughly $45 billion – about a quarter of all spending on World War II munitions (Koistinen, 2004, p. 38). The question is how much relevance this had for manufacturing – either civilian or military – after the war. Wikipedia has compiled a list of most-produced aircraft, enumerating those with production runs greater than 5,000 (Wikipedia, 2017a,c). Twenty-one World War II aircraft in the United States meet this criterion: five bombers (two heavy, two medium, one light), eight fighters, three dive or torpedo bombers, three trainers, a transport aircraft, and a glider. These are described below, with production totals in parentheses, along with information on the year in which production ceased.

The two heavy bombers were the Boeing B-17 Flying Fortress (12,731) and the Consolidated B-24 Liberator (18,482). The two medium bombers were the North American Mitchell (9,984), and the Martin B-26 Marauder (5,288). The light bomber/intruder aircraft was the Douglas DB7 (A-20 Havoc) (7,478). Production of all of these aircraft ceased in 1945, with the exception of the Douglas, for which production ceased in 1944. Each of these aircraft had been fully designed, tested, and flown prior to Pearl Harbor (Wilson, 2016, p. 58).[11] These bomber production runs exceeded by two orders of magnitude those common in the postwar period.[12]

[11] The only heavy bomber that had not flown prior to Pearl Harbor, was the B-29, 3,970 of which were built. This was the aircraft that delivered atomic bombs to Hiroshima and Nagasaki, as well as the Abel airblast at Bikini atoll in July of 1946. Production of B-29s ceased in 1946.
[12] For example: the B-52: 742 (1952-62); the B-1A and B: 104 (1973-4, 1983-88); the B-2: 21 (1987-2000) (years of production in parentheses).

Eight World War II fighters had production runs of more than 5,000: the Grumman F4F Wildcat (~7,800), the Curtiss P-40 Warhawk (13,738), the Chance-Vought F4U Corsair (12,571), the Grumman F6F Hellcat (12,275), the Lockheed P-38 Lightning (10,037), the Republic P-47 Thunderbolt (15,660), the North American P-51 Mustang (15,586), and the Bell P-39 Airacobra (9,584). Production of all of these aircraft had ceased by the end of 1945, with the exception of the Mustang and the Corsair, which remained in production until 1951 and 1952 respectively. All of these aircraft had been designed before the war. With the exception of the P-47, F4U, and F6F, all had flown prior to Pearl Harbor.

The Douglas SBD Dauntless dive bomber (5,936) and the Curtiss SB2C Helldiver (7,140) ceased production in 1945; the Grumman TBF Avenger torpedo bomber (9,837) in 1944. All three had flown prior to Pearl Harbor.

The Douglas C-47, the military transport version of the DC-3, remained in production until 1952, but the rate of production slowed greatly after the war. Total production was 16,079, including 607 civilian versions (DC-3s completed in 1942 or earlier), 10,048 C-47's built in the United States during the war, and 4,937 under license by the Soviets.

Three small training aircraft also continued to be built after the war. The North American T-6 Texan (15,495) remained in production into the 1950s. The Vultee BT13 Valiant (11,537) ceased production in 1947, and the Fairchild PT-19 (~7,700) in 1948. Finally, ~ 13,900 Waco CG-4 gliders were produced, with production ceasing in 1945.[13]

[13] See Smith (1959, p. 27) for statistics on Army aircraft production very slightly lower but in close agreement with the comparable statistics from Wikipedia.

Constructing over 276,000 aircraft between 1942 and 1945 was a notable achievement. During 1944, the United States completed an airplane on average once every five and a half minutes (Walton, 1956, p. 540).[14] But none of the experience acquired in producing these models can have had much bearing on US productivity levels and growth in the postwar period, because production of almost all ceased prior to or shortly after the end of the war. Nor had the war effected a dramatic acceleration in the design process. Every military aircraft experiencing significant World War II deployment had been fully designed prior to the war, and, as noted, all but four (the B-29 and the three fighters mentioned above) had been flight tested or were already in active service prior to Pearl Harbor.

What about category 2 experience – gains relevant perhaps not to the manufacture of specific aircraft per se, but to the manufacture of aircraft more generally? This was, after all, an industry in which the United States became a world leader after the war, with consequences that transformed regional economies, particularly in the West. It is important in this regard to appreciate the unusual and indeed unique characteristics of World War II aircraft manufacture. The country – indeed the world – never again produced such vast quantities in such a compressed time frame. In the postwar period, a very small number of aircraft models have approached or exceeded cumulative production runs of 5,000, and most of those that did were small single engine aircraft produced for the general aviation market: Beechcraft, Cessnas, Pipers, and Aeroncas.

After World War II, only four military aircraft experienced production runs greater than 5,000: the North American F-86 Sabre (9,860, 1947-56), the Republic F-84 Thunderjet (7,524;

[14] The US produced 301,572 aircraft between 1940 and 1945. 6,086 were produced in 1940, and 19,433 in 1941. Peak production was in 1944, when the US manufactured 96,318. (Wikipedia, 2017b). The statistic cited by Walton is simply a matter of division. There are 525,600 minutes in a year. 525,600/96,318 = 5.45.

1946-53), the McDonnell-Douglas F-4 Phantom II (5,195; 1958-81) and the Lockheed T-33 Shooting Star jet trainer (6,557; 1948-59). More typical, as noted, was the subsonic heavy bomber, the B-52, originally built between 1954 and 1963, with a cumulative production run of 742. Only one US commercial aircraft has exceeded cumulated output of more than 5,000 in the postwar period. The production run of the Boeing 737 began in 1967 and as of August 2017 approached 9,700. That cumulative output, however, has taken place over half a century, not two or three years.

Some compromises, moreover, had to be made to enable the extraordinary wartime rate of throughput. Mass producers of aircraft from the automobile industry, particularly Ford at the huge and problem-plagued Willow Run facility, pushed back against the military's steady stream of change orders and eventually refused to accommodate more of them. A consequence was that thousands of aircraft rolled off the production line and were then flown immediately to one of 19 modification centers. Newly installed equipment was ripped out and replaced, and other changes made, some that customized the aircraft for its intended theatre of operations (Walton, 1956, p. 249), but many because mass manufacture was simply not compatible with the frequency of change requests desired by the military.[15] There is little evidence that World War II experience had persisting beneficial influence in the postwar period either in how aircraft were designed or in how they were built.

The story is similar in the case of ship production. Between 1941 and 1945 eighteen shipyards in the United States produced 2,710 Liberty ships. No other ship model before or since

[15] Ferguson (2005) provides a nuanced treatment of the different approaches to production taken by aircraft manufactures and General Motors as opposed to Ford. He makes it clear that, contrary to Ford's optimistic assertions, the manufacture of aircraft bore little relation to that of automobiles. Thus the flow rate of output is somewhat overstated, since many of these planes had to be partially deconstructed and retrofitted before they could be used.

has ever approached this record of cumulated output (the Liberty ship was based on an 1879 British design). The gains in labor productivity were partly enabled by replacing rivets with welds; the remainder has traditionally been attributed to more mundane learning by doing. But as in the case of aircraft, we must be cautious in waxing too enthusiastically about Liberty ship production successes. Thompson (2001) suggests that much of the measured labor productivity improvement over time was due to quality deterioration and capital deepening. The quality deterioration was evident in the more than 100 Liberty ships that sank within ten years of launch due to hull or deck fractures attributable to poor welds. Even if we acknowledge significant learning by doing in producing these vessels, such knowledge was of questionable relevance after the war because the US economy has never been and likely never will be faced again with the challenge of producing so many similar ships in such a short period.

US shipyards, including those owned and operated by the US Navy, also produced a prodigious number of naval vessels between 1941 and 1945 inclusive: 31 aircraft carriers, 6 battleships, 42 battle, heavy, and light cruisers, 302 destroyers, 191 submarines, and 78,242 landing craft (U.S. Department of Commerce, 1947, table 247, p. 222). The relevance of this to the postwar economy, civilian or military, is also questionable. As in the case of aircraft, in the postwar period the US built many fewer but far more expensive combat vessels.[16]

We can conclude that the gains in category 1 were significant, in category 2, moderate, and in category 3 almost entirely absent. Gains in category 3 had the greatest potential for persistence and general applicability. But there is scant evidence that organizational breakthroughs during the war, which would show up in TFP, help explain success after it. We

[16] The US Navy currently (2017) operates 10 aircraft carriers.

can get some perspective on this by examining the changing share of "other transportation equipment" (all transport equipment except automobiles) in US manufacturing. In 1941, in spite of Lend Lease and pre-Pearl Harbor increases military spending, the category comprised just 2.2 percent of total manufacturing output. At its peak in 1944 that share had risen to 20.7 percent of a considerably expanded manufacturing sector. By 1948 it had fallen back to 2.7 percent (see also Field, 2011, tables 3.3 and 3.4). Even at the height of the Korean War in 1953, the share rose only to 6.9 percent of manufacturing output, or 2.4 percent of the private nonfarm economy (U.S. Department of Commerce, 1966, Table 1.12, p. 19).

TFP in manufacturing had been growing rapidly between 1929 and 1941 – more rapidly than at any other period with the exception of 1919-1929. Field (2011, table 2.3, p. 54) reported TFP growth in US manufacturing of 5.12 percent per year between 1919 and 1929, 2.76 percent per year between 1929 and 1941, and -.35 percent between 1941 and 1948, reviving only to 1.49 percent during the golden age (1949-73). Recalculation of the 1941-48 rate, using slightly different data (see the Appendix) indicates a slightly more negative rate of advance (-.55 percent per year). If Gordon is right, we would expect 1948 manufacturing TFP to have exceeded its level in 1941, perhaps substantially. The decline in manufacturing TFP across the war years is a particularly compelling piece of evidence against his views.

The Legacy of Wartime Capital Accumulation

The war resulted in an enormous accumulation of physical capital in the form of military hardware, producer durables such as machine tools and dies, and industrial structures, such as the massive Willow Run facility built near Detroit. In addition, the country experienced a large increase in physical capital associated with military command structures, forts, and bases. The utility of this capital after the war is an important question, both in cases where the capital was potentially dual use, and might contribute to postwar non-military production, and where it could only be used for military purposes. In the latter case, if a large accumulated stock of military ships, tanks, aircraft, hardware and structures produced or constructed during the war made it possible subsequently to devote a smaller share of US production capability to the manufacture or construction of such goods, that stock could, after the war, have allowed for greater accumulation of government infrastructure complementary to private production, or production and acquisition by the private sector of physical capital useful in civilian production.

With the exception of B-29 bombers, most of the aircraft produced during the war were, at its conclusion, deemed obsolete and declared surplus. Tens of thousands were flown to 'boneyards' in Arizona – air bases such as Kingman and Davis Montham. Engines were removed for steel scrap and the airframes guillotined, fed immediately into onsite smelters where the metal reemerged as aluminum ingots. Towards the end of the war some aircraft were flown directly from the factory gate to Arizona for disassembly and recycling. Many aircraft operating overseas were never repatriated. Abandoned in their theatre of operation, it was simply not worth the cost in fuel and manpower to fly them back to the states so they could be scrapped. Similar fates befell Liberty ships (scrapped and recycled for the steel), tanks, and other military equipment.[17] These goods had been produced to fulfill an extraordinary need. With the war ended, so did most of that need.

It was not just aircraft and freighters   What do the following naval vessels have in common, along with several captured German and Japanese ships?

[17] Weyerhauser maintained a small fleet of Liberty ships after the war, but surplus Liberty ships made more of a contribution to the postwar Greek and Italian merchant marines than they did to that of the US. Aristotle Onassis got his start by acquiring several. Most of the remainder were mothballed and ultimately scrapped.

Aircraft carriers: USS Saratoga, USS Independence
Battleships: USS Arkansas, USS Nevada, USS New York, USS Pennsylvania
Cruisers: USS Pensacola, USS Salt Lake City
Destroyers: USS, Anderson, Conyngham, Hughes, Lamson, Mayrant, Mugford, Mustin, Ralph Talbott, Rhind, Stack, Trippe Wainwright, and Wilson
Submarines: USS Apogon, Dentuda, Parche, Pilotfish, Skate. Skipjack, Tuna
Atack Transports: (19)
Landing Ship Tanks (LSTs): (6)
Landing Craft Tanks (LCT): 16
Miscellaneous naval vessels (21)

They were destroyed or made so severely radioactive that almost all had to be scuttled as the result of two atomic blasts (Operations Crossroads), an airblast on July 1, 1946 (Abel) and an underwater detonation on July 26, 1946 (Baker). Several were sunk immediately at Bikini as the result of the first or second blast. Most of the rest were towed to Kwajalein (about 400 kms) for tests, and then scuttled. A few were brought to Pearl Harbor or West Coast US harbors before being used for target practice and then sunk. Two submarines and four smaller ships were successfully decontaminated and sold for scrap. The tests had been designed to demonstrate that naval vessels could survive nuclear bombs, thus countering claims that such ships were obsolete in the atomic age. The tests demonstrated the opposite, and the third planned shot was cancelled. At the time some members of Congress complained that tons of steel that could otherwise have been recycled went to the bottom of the ocean (Weisgall, 1994, pp. 77-78; 317-322).

As thousands of tons of obsolete or no longer needed military equipment lay parched on the Arizona desert, as hundreds of rusting Liberty and naval war ships prepared for scrappage, or targets for atomic bombs, the knowledge that was acquired in building these durables also dissipated. Creative destruction is a feature of production knowledge as much as it is of products, and was particularly severe under the extraordinary conditions of World War II production and its aftermath.

What of the enormous production of machine tools paid for by the government? Machine tool output increased two orders of magnitude during the war. Annual production during the Depression was approximately 7,000 per year, generated by roughly 200 specialized firms. In 1940, 110,000 were produced, and in 1941, 185,000. At the peak of production in August of 1942, machine tools were being generated at an annual rate of 365,000, although by 1944, more than a year before the war ended, production had already fallen back to less than half the peak rate (Walton, 1956, p. 229; see also Ristuccia and Tooze, 2013, table 1).

There was indeed a huge investment in plant and equipment by the government (some of the GOCO capital whose consequences Gordon began his career examining). But the mass production techniques that made volume production of tanks and aircraft possible in the United States relied overwhelmingly on single purpose machine tools, and the majority of these tools and related jigs and frames were scrapped with reconversion.[18] The US did use multipurpose machine tools, which could more easily be repurposed, but principally in the shops producing machine tools.

The Scrappage Problem

Already beginning in 1944, the country confronted serious surplus and scrappage issues. By early 1945 disposal agencies had surplus inventories of roughly $2 billion dollars – equivalent to the entire cost of the Manhattan Project. By V-J day that had risen to $4 billion. Surplus inventories peaked at $14.4 billion in mid-1946 (Cook, 1948, pp. 10-11). Most military hardware, with the exception of jeeps and trucks, was not dual use. Automobile manufacturers, in any event, lobbied against repatriation of such vehicles, concerned they would spoil the

[18] Again, see Ferguson (2005, p. 166) for a nuanced discussion of variation among manufacturers in these practices.

postwar market. A few tanks were converted to tractors or bulldozers. Overall, recycling and disposal posed huge logistical challenges.

What, more generally of the billions of government funded equipment and structures built to produce all the military hardware? Gordon (1969) suggested that government statisticians had not adequately reckoned the value of this capital in considering the contributors to postwar production. To the degree we insist on adjusting upward the growth of the capital stock relevant to private sector production, higher capital growth rates will further reduce the already negative rates of measured TFP advance within manufacturing between 1941 and 1948. Moreover, if our measures of the growth of private sector capital are biased downward, we would still expect to see strong effects in the growth of labor productivity (because of higher 'true' rates of capital deepening). For US manufacturing, table 1 shows that labor productivity growth between 1941 and 1948 was effectively nil (.04 percent per year).

A large fraction of the government investment in plant and equipment was of little value in the postwar period. That is why so much of it was scrapped, or sold for pennies on the dollar in the postwar period. A competing narrative suggests these were giveaways, sweetheart deals for large military contractors. Gordon (1969, p. 224), for example, suggests that private firms might have chosen the five-year amortization of capital improvements offered to them by the government because they were concerned postwar demand would render their capacity excess. His discussion does not adequately address the likelihood that manufacturers correctly anticipated that their new equipment and structures would be only imperfectly suited, or in some cases not suited at all to the postwar production mix. A careful reading of the literature suggests that the prices at which industrial plant was disposed of were generally reasonable. Disposal took place amid strong political currents favoring antimonopoly and the encouragement of small business. The aluminum industry, in particular, was restructured on a more competitive basis than had been the case prewar, an outcome anticipated from the start: unlike other GOCO contractors, ALCOA had not been given an option to buy the new government plants it operated.

The problem of scrappage extended not just to the tools of war but also to the tools and parts that made them.   Often the cost of scrappage was greater than the quantity of recoverable materials. But inaction was not an option, because unless the now obsolete or no longer needed parts and equipment, machine tools and dies, and finished tools of war were cleared out and disposed of, they would clog production facilities and adversely impact the revival of civilian production. Scrappage was already a serious challenge prior to VJ day. Change orders for tanks or bombers could instantly obsolete assembled parts, tools, jigs and frames, as well as completed (but now obsolete) units. Mass production techniques pioneered in the 1920s and 1930s and used to build military equipment in the 1940s relied on single purpose jigs, frames, and machine tools. These were of no more use after the war than most of the military equipment they had helped produce, or the jigs, frames and machine tools used to produce cars that had been ripped out and recycled in 1942.

Why were government plants sold for only a fraction of their construction cost? Part of the explanation is that there was often only a single bidder. But another reality is that they were often not ideally suited to the needs of postwar production. Plants had been constructed to manufacture a product mix some of which would never return.   Some were not built to last more than a few years. They were dispersed around the country to protect them from bombing, a questionable precaution given the new realities of military technology. A prime example was the Geneva steel mill built in Vineyard, Utah, a heavily polluting white elephant operated by US Steel during the war and bought by the company in 1946 for what critics said was a fraction of its worth (after being sold in 1987 it ceased operations in 2002). Even within an aircraft production facility, the locations of individual structures were uneconomically dispersed, to make the facility less vulnerable to air attack. Government built industrial facilities after the war did have value, but it was on average a fraction of their cost of construction.

The conflict also left the country with a vastly expanded network of military structures, a physical plant substantially in excess of the country's needs in the postwar period. The Pentagon, completed in 1943 at a cost of $78 million, was the small tip of a very large iceberg. As of June 30, 1945, the Army had spent within the United States $7.2 billion on command (non-industrial) plant. This total compares with $8 billion for industrial facilities, of which $7 billion was for government plants and $1 billion for equipment in privately owned plant. Along the way, the Army acquired ownership of additional acreage in the country exceeding the combined area of the six New England states (Smith, 1959, pp. 441, 444, 447). Once built, new forts and bases created political coalitions in favor of their retention. It took decades, including the establishment of multiple Base Realignment and Closure Commissions, for the country to make a dent in that surplus.

TFP, Hours, and Physical Capital

The fundamental growth accounting equation tells us that growth of output can be decomposed into contributions from the growth of total factor productivity, the growth of hours, and the growth of capital. As has been noted, TFP in manufacturing declined between 1941 and 1948, and that is the sector in which we would most have expected to see longer run consequences of the wartime production experience. TFP in manufacturing did of course eventually increase in the postwar period, but it did so at a much slower rate than had been true during the interwar period. The BLS historical multifactor productivity tables for manufacturing

(2004) show TFP in the sector growing at 1.49 percent per year between 1949 and 1973 – less than half the growth rate during the 1930s (1929-41), and less than a third what it was during the 1920s (1919-29). In the interwar period the growth of manufacturing TFP was consistently above the average for the private nonfarm economy. In the golden age (1949-73) it was persistently below it. If we look ahead all the way to the first decades of the twenty first century (table 9), we see an unmistakable downward trend in manufacturing TFP growth, undisrupted by the war, and interrupted only briefly by the decade long IT boom beginning in 1995.

TFP growth in manufacturing between 1929 and 1941 was lower than between 1919 and 1929, but far exceeds what took place in any other comparable period. The war sharply reversed this, with negative advance between 1941 and 1948. During the golden age of US living standard improvement, 1949-1973, TFP growth in the sector was less than half what had been achieved across the depression years (1929-41). Advance dropped to two thirds of a percent per year during the dark ages between 1973 and 1995 before reviving for a decade during the IT boom, but has been mildly negative between 2005 and 2015. The long term declining trajectory of growth rates is strongly suggestive that the experience of war production retarded productivity growth and the growth of potential output from this source after the war.

Perhaps one can argue that the modest rate of TFP advance in US manufacturing after the war would have been even more modest in its absence. A more plausible interpretation of the impact on potential output emphasizes the decline in manufacturing TFP between 1941 and 1948 and advance between 1949 and 1973 at less than half its rate between 1929 and 1941 and a third its rate between 1919 and 1929, along with the war's distorted contribution to physical capital accumulation, and finally, its negative effect on potential hours.

The immediate postwar impact of the war on potential hours was clearly negative. 607,000 service people suffered wounds, and 405,399 mostly prime age males never returned. Most would have been alive in the absence of the war. The 50 percent wartime rise in female labor force participation (Schweitzer, 1980, p. 90) largely dissipated during the immediate postwar period. One can of course, speculate that the military casualties along with the war's effect in cleaning up household balance sheets played some role, over the longer run, in the fertility revival that led to the baby boom, which led to some compensatory acceleration of potential output growth a decade and a half later.

The counterfactual with respect to capital is complex. The country emerged in 1948, inter alia, with a vastly expanded aluminum production industry and a reduction in its industrial concentration, a synthetic rubber capability that had been developed basically from scratch, and the Big Inch and Little Inch pipelines, bringing crude oil and refined petroleum products from East Texas to the East Coast.[19] But both public and private capital accumulation in areas not militarily prioritized had been repressed. Military production priorities starved the economy of government investment in streets and highways, bridges and tunnels, water and sewage systems, hydro power and other infrastructure that had played such an important role in the growth of productivity and potential across the depression years. These categories of government capital complementary to private capital grew at a combined rate of .15 percent per year between 1941 and 1948, as opposed to 4.17 percent per year between 1929 and 1941 (BEA Fixed Asset Tables,

[19] Between 1939 and 1943, capacity in the aluminum industry increased seven-fold, from 325 million pounds per year to 2.3 billion pounds per year. This contributed critically to US dominance in military and commercial aviation after the war. The new synthetic rubber industry was created in response to the cut off during the war of access to natural rubber supplies in the Far East. Output increased from 28 million tons in 1942 to 922 million tons in 1945 (Koistinen, 2004, pp. 138, 149). The Big Inch and Little Inch pipelines transported fuel without exposing it to the risk of submarine predation off the Gulf and Atlantic coasts.

tables 7.1 and 7.2). Portions of the private economy not deemed critical to the war effort also subsisted on a thin gruel of new physical capital. Trade, transportation, and manufacturing not directly related to the war are cases in point. Private nonfarm housing starts, which had finally recovered to 533,200 in 1941, close to the 1925 peak (572,000), plunged to 114,600 in 1944, barely above the 1933 trough of 76,000 (National Bureau of Economic Research accessed via FRED, 2017).

Higgs (2010) adds an additional twist to this argument by emphasizing the wear and tear on the capital stock caused by double and triple shifts, and the understatement of depreciation allowances caused by the repressed inflation during the war. Once price controls were removed and inflation accelerated between 1945 and 1950, those allowances were inadequate to repair the ravages of intensive wartime utilization.

Conclusion

The use of the word ‘miracle’ to describe US war mobilization took shape in 1942, in an address by Eugene Wilson, CEO of United Aircraft. Picking up on this theme, the Ford Motor Company ran advertisements describing its production efforts as “the greatest miracle of mass production the world has ever seen.” In his January 1943 SOTU address, Roosevelt used similar words, referring to the “miracle of production” (Wilson, 2016, p. 106) The spread of this language was in part the result of efforts led by the US Chamber of Commerce to insure that private business got all or most of the credit for winning the war, even though production was very much a joint government – industry effort.

Symptomatic of this was insistence that the names of all military aircraft begin with the name of the prime contractor,[20] even if the aircraft had been largely designed and tested by government personnel, and even if the manufacture was in plants and with equipment entirely owned by the US government (the practice was never successfully extended to naval vessels, tanks or other land vehicles). Contrary to the situation today, the US Navy built roughly half its warships in its own government owned and operated shipyards, and the US Army controlled arsenals where design, testing and some production of weaponry, particularly artillery and small arms, took place. Outside of the Navy Yards and Army Arsenals, production took place largely within plants wholly owned by the US government, which by the end of the war comprised between 15 and 25 percent of US manufacturing capacity (Wilson, 2016, p. 258). Tens of thousands of US government employees, both military and nonmilitary, negotiated contracts, audited books, inspected output, and in some cases, with the backing of armed soldiers, took over production facilities where labor or other problems threatened the war effort.

The ‘economic miracle’ narrative, which Gordon whole-heartedly embraced, emerged against the backdrop of a continuing contest over how to organize, characterize and credit the production successes. Business leaders were so focused on this that they actually began expressing unease about references to ‘miracles’, believing it did not fully credit the contribution of the production experience gained in “150 years of free enterprise” prior to the war, as put by the president of the National Association of Manufacturers in a speech in December of 1943 (Wilson, 2016, p. 106). Private sector leaders systematically omitted reference to or denigrated the contributions of government personnel. While their repeated insistence that achievements were in spite of the bureaucratic hamstringing of government officials is questionable, the

[20] A number of aircraft models were produced by more than one contractor.

business leaders' claim that success depended on prior production experience and their eventual push back against appeals to the supernatural had merit.

Although the war effort did leave the economy with some assets that benefited postwar production capability, it distorted physical capital accumulation, crowding out investment in sectors of the economy not critical for the military effort. The US suffered more than a million military casualties. On the home front, the increase in the female labor force between 1940 and 1944 proved to be a flash in the wartime pan. As the Appendix documents, between 1941 and 1948 total factor productivity deteriorated in manufacturing and construction, and in the aggregate, grew more slowly than had been true between 1929 and 1941. A longer-term impact on TFP of learning by doing in wartime production is doubtful, because the output mix as well as factor prices differed after the war, and there were few spillovers from this learning to the production of other products.

The war was in fact an enormous and often tragic waste of human and physical resources. Economically disruptive, it greatly distorted the economy for a period of several years, as sectors critical to the war effort expanded several-fold and then as rapidly shrunk. Gordon argued that "the case is overwhelming for the economic miracle interpretation of World War II along every conceivable dimension…" What the United States accomplished in the production of military hardware was indeed exceptional. But the impact on the growth of U.S. potential output of this unique and never to be repeated experience was almost certainly retardative.

APPENDIX

This appendix details the calculations underlying the conclusion that TFP in manufacturing between 1941 and 1948 declined, estimates TFP growth in other sectors during this same period, and examines sectoral contributions to private nonfarm economy TFP growth between 1941 and 1948. The exercise differs from the discussion of trends in aggregate TFP discussed in the main body of the paper. First, there is no attempt at the sectoral level to make cyclical adjustments for the level of TFP in 1941. Second, as in Field (2011), the calculation of sectoral contributions to aggregate TFP growth does not utilize the newer chained index measures of output. Such data are not available at the sectoral level for these time periods. Finally, the approach uses single rather than double deflation. The Bureau of Economic Analysis's preferred method for calculating sectoral output growth in the GDP by industry section of its website is to deflate the nominal value of gross output, deflate the nominal value of intermediate inputs, and treat the difference between the deflated series as real value added. Whatever the merits of this method, data available prior to 1947 will not support it, so the approach followed, in instances where the calculations go beyond index numbers available in Kendrick (1961), is single deflation of nominal income generated in a particular sector.

We begin by examining productivity growth between 1941 and 1948 in comparison with the depression years (1929-41) for the following sectors: manufacturing, wholesale and retail trade, and railroad transportation. According to Field (2011, table 2.5, p. 59), these three sectors accounted for over 90 percent of total TFP growth in the private nonfarm economy between 1929 and 1941. We then look as well at trucking and warehousing, electric and gas utilities, mining, and construction. Table 8 brings these sectoral estimates together and estimates their respective contributions to aggregate TFP growth.

Productivity Growth in Manufacturing: 1929-41 and 1941-48

As noted, Kendrick has TFP growth in manufacturing at 5.12 percent year between 1919 and 1929, a figure accepted by Abramovitz/David, Field, and Gordon. Although Kendrick provides annual data on output and hours inputted, his capital input series, based on Creamer et al (1960), has a level for 1937 and then again for 1948 but not the intervening years. To calculate a growth rate of total factor productivity to and from 1941, one needs series on output growth, labor input growth, and capital input growth, as well as labor and capital shares that can be used to weight growth rates of the latter two series. In these calculations, capital's share is assumed to be .3.

The 1966 Department of Commerce publication, The National Income and Product Accounts of the United States, 1929-1965, provides data on nominal income by sector going back to 1929. The National Income and Product Accounting identities guarantee that nominal income generated by a firm or sector is equivalent to that firm or sector's value added, and thus its contribution to gross product. For manufacturing, nominal income in the durables and nondurables subsectors (table 1.12, lines 13 and 24) are converted to real value added using deflators for each subsector (table 8.6, lines 2 and 14; 1958=100) and then summed. This yields an estimate of the growth of manufacturing output of 4.43 percent per year between 1929 and 1941, and 1.98 percent per year between 1941 and 1948. Note that in the latter calculation we are measuring from premobilization to the first fully employed post-demobilization year. We are not measuring from 1941 to 1943 or 1944, because the question is not whether the United States succeeded in producing extraordinary flows of military hardware in a short time and experienced productivity gains in doing so (it did), but whether that experience positively influenced productivity levels and rates of growth in the postwar period.

Labor input is calculated in the following fashion. FTEs in the sector are drawn from BEA NIPA Table 6.5a. These numbers are identical to those in Department of Commerce 1966, table 6.4 line 11, except for a small difference for 1948. A difficulty with using FTEs as a proxy for hours input is that average weekly hours of work change over time. Data in series Ba4580 from Historical Statistics of the United States, Millennial Edition show average weekly hours in manufacturing declining from 44.2 in 1929 to 40.6 in 1941 to 40.2 in 1948. To create a proxy for hours, FTE numbers for 1941 are reduced by multiplying by the ratio of average weekly hours in 1941 to average weekly hours in 1929 (.919). FTE numbers for 1948 are reduced by multiplying by the ratio of average weekly hours in 1948 to average weekly hours in 1929 (.909). Based on these calculations, labor input in U.S. manufacturing grew between 1929 and 1941 at 1.22 percent per year, and between 1941 and 1948 at 1.94 percent. These are very close to growth rates based on Kendrick's manhours series for manufacturing (1.23 and 1.96 percent per year for the two periods respectively). Since we now have estimates of the growth rate of both sectoral output and hours, we can estimate labor productivity growth (their difference) as 3.22 percent per year between 1929 and 1941, and .04 percent per year between 1941 and 1948.

To estimate TFP growth, we also need to know how fast capital input was growing. The BEA's Fixed Asset Table 2.2 provides chain type quantity indexes for the net stock of private fixed assets, enabling calculation of the growth of the real stock of industrial equipment (line 11) and manufacturing structures (line 48). These growth rates are then combined, weighting them by the average shares of equipment and structures in the manufacturing capital stock, based on values from the BEA's Fixed Asset table 2.1, Current Cost Net stock of Private Fixed Assets. This yields manufacturing capital growing across the depression years at 1.11 percent per year and 3.90 percent per year between 1941 and 1948.

Putting these three series together in the standard growth accounting framework, and weighting capital growth by .3 and labor input growth by .7, we have manufacturing TFP growth of 3.25 percent per year between 1929 and 1941, and -.55 percent per year between 1941 and 1948 (table I). These numbers differ slightly from the 2.76 per year between 1929 and 1941 and -.35 percent per year reported by Field (2011).[21] Neither set of estimates is consistent with the Gordon narrative. Table 8 combines sectoral TFP growth rate estimates with data on sectoral shares in the private nonfarm economy, permitting calculation of percentage point contributions to aggregate TFP growth. Between 1941 and 1948, the manufacturing sector contributed -.21 percentage points per year to PNE TFP growth.

Wholesale and Retail Trade

We adopt a similar approach for wholesale and retail trade. Nominal income generated in the sector is from Department of Commerce 1966, table 1.12. These flows are deflated by the personal consumption expenditure (PCE) deflator (Department of Commerce, 1966, table 8.1, p. 158). This shows real output growing in the sector at 3.2 percent per year between 1929 and 1941, and 5 percent per year between 1941 and 1948. For labor input, FTEs for both wholesale and retail trade are drawn from BEA NIPA Table 6.5A. It is not possible to adjust the 1941 FTEs for changes in the average hours per week, but retail FTEs for 1948 are adjusted downward because of the decline from 42.8 to 40.2 hours reported in HSUS Series Ba4580. We have labor input growing at 1.5 percent per year between 1929 and 1941, and 2.7 percent per year between

[21] The higher TFP growth rate between 1929 and 1941 compared with Field (2011) is principally driven by the measure of output growth in the calculations described above (4.43 percent), which exceeds that calculatable from Kendrick's table D-II (3.81 percent), which was used in Field (2011). For 1941-48, the 1.98 percent per year output growth calculated here is slightly less than a rate based on Kendrick's output index, which grows at 2.20 percent per year over that period.

1941 and 1948. Together with the output growth numbers, we can estimate labor productivity growth at 1.64 percent between 1929 and 1941 and 2.23 percent between 1941 and 1948.

Capital input is estimated from BEA Fixed Asset Table 2.2, lines 44 (multi-merchandise shopping structures) and 46 (warehouses). Growth rates for the two series are combined, weighted according to the average value of these two components at the beginning and end of each period (BEA Fixed Asset Table 2.1). We have capital growing at -.8 percent between 1929 and 1941, and -.9 percent between 1941 and 1948. Bringing all three series together, and assuming a capital share of .3, we have TFP growing at 2.27 percent per year between 1929 and 1941, and 3.26 percent per year between 1941 and 1948 (table 2).

Because of its relatively large size and robust rate of TFP advance, the sector contributed .71 percentage points to PNE TFP growth between 1941 and 1948 – the largest contribution of any sector. In contrast to manufacturing, labor input in trade declined through 1942 and 1943 before beginning to recover, although FTE levels in both subsectors were still lower in 1945 than they had been in 1941. And in contrast to manufacturing, capital input declined. The fact that productivity growth between 1941 and 1948 was much higher in trade than in manufacturing suggests that sectoral productivity advance across the war years may have had more to do with learning by doing without than with learning by doing.

For railroads (table 3), a sector which, in contrast with 1917-18, performed well during the war, productivity growth remained about as high between 1941 and 1948 (or 1950) as it was during the 1929-41 period. The huge loads carried during the war represented a swan song for American railroads, at least with respect to passenger traffic, which began dwindling in the 1950s until all that remained were a few subsidized routes run by Amtrak. But productivity growth in freight transportation after the war remained respectable (Field, 2011, pp. 112-115).

Faced with exceptionally strong demand and tight labor availabilities, the sector was able to extend the trajectory of advance displayed between 1929 and 1941 (2.56 percent per year between 1941 and 1948 vs 2.94 percent in the earlier period). The Depression years had seen a shift toward diesel electric motors and progress toward unlimited freight interchange, and systematic rationalization in which hours, locomotives, and rolling stock all declined by a quarter or a third, while output changed hardly at all. Here the data is drawn from Kendrick; in contrast to the two previous sectors, Kendrick has annual data in levels throughout the relevant time intervals. The sector contributed .11 percentage points per year to PNE TFP advance.

Trucking and warehousing (table 4) takes output and employment from Kendrick, and capital from BEA FAT table 2.2, line 19: trucks, busses, and light trailers. Data limitations in Kendrick require measuring to and from 1942 rather than 1941, and the use of employment numbers rather than hours for labor input. They show TFP growth retreating from the torrid advance between 1929 and 1941 of 12.61 percent per year to a still very strong 3.36 percent per year between 1942 and 1948. The sector contributed .04 percentage points per year to PNE TFP growth between 1941 and 1948.

The analyses of the electric and gas industries (table 5) are also based on Kendrick. Both sectors had experienced strong growth in TFP between 1929 and 1941, and growth continued at a slightly higher rate between 1941 and 1948: 5.87 percent for electric, and 5.45 percent for gas. In the absence of a better way to do this, these growth rates are weighted by data on the number of employed persons in the respective subsectors in 1929 (Kendrick, 1961, table H-X). Even though the sector is roughly half the size of railroads, the high rate of TFP advance means that utilities contributed .13 percentage points to PNE TFP growth, as compared with railroads' .11 percentage points.

Mining is covered in table 6, with output and hours from Kendrick, and capital from the BEA's Fixed Asset Table 2.2. TFP growth fell to .64 percent per year between 1941 and 1948 as compared with 2.09 percent per year between 1929-41. Because of its relatively small share and modest TFP advance, the sector's contribution to PNE TFP growth is a negligible .02 percentage point.

Finally, construction (table 7). The Depression years had been a dismal period for construction, with TFP declining at .91 percent per year. Measuring between 1941 and 1948 the situation got worse, with TFP falling at 2.71 percent per year, contributing -.15 percentage points to the overall PNE TFP growth rate.

The remainder of the private nonfarm economy (sectors not covered in tables 1-7) is split between finance, insurance and real estate (10.1 percent), transportation services other than railroads and trucking (1.9 percent) and other services not elsewhere classified (10.7 percent), for a total of roughly 23 percent of the PNE. Based on Kendrick's data, PNE TFP growth between 1941 and 1948 was 1.29 percent per year.[22] The sectors discussed in tables 1-7 contribute on net .69 percentage points, implying .60 percent points in the residual sector, which in turn implies a 2.65 percent annual TFP growth in the residual services category (see table 8).

Between 1941 and 1948 the biggest percentage point contributors to PNE TFP growth were wholesale and retail trade, followed by the residual service category, electric and gas utilities, and railroads, with much smaller contributions from trucking, telephone and telegraph, and mining. TFP growth was negative in manufacturing, and strongly negative in construction. A cocktail of very strong demand, tight labor availabilities, and capital growth that was crowded

[22] Note that because I have not attempted cyclical adjustments for the sectoral estimates, I am also not including a cyclical adjustment for the aggregate growth rate here.

out seems to have been a more powerful stimulus to TFP growth over the course of mobilization and demobilization than the disruptive and temporary imposition of a new product mix combined with massive government infusions of equipment and structures and priority access to and allocations of materials and labor within wartime manufacturing.

As described in the text, table 9 summarizes TFP growth in manufacturing for different periods from 1919 through 2015, documenting the generally downward trend over the past century.

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Table 1

Manufacturing Productivity Growth: 1929-41; 1941-48

		Nominal Output	Nominal Durables	Deflator -1958=100 Durables	Nondur	Real Output	FTEs	Adjusted FTEs	Manu Capital	Labor Prod.	TFP
Levels	1929	21945	11303	56.4	54.5	39567	10428	10428	10.136		
	1941	33211	20317	50.4	47.7	67343	13137	12067	11.576		
	1948	67571	35448	86.4	88.5	77349	15276	13824	15.209		
Growth Rates											
	1929-41					0.0443		0.0122	0.0111	0.0322	**0.0325**
	1941-48					0.0198		0.0194	0.0390	0.0004	**-0.0055**

Sources: Nominal Output: Department of Commerce, 1966, table 1.12

Deflators (1958=100): Department of Commerce, 1966, table 8.6

FTEs: Bureau of Economic Analysis: NIPA Table 6.5

FTEs adjustment: HSUS, series Ba4580

Capital: Bureau of Economic Analysis, Fixed Asset Table 4.2, line 9

See text for full description.

Table 2
Productivity Growth in Wholesale and Retail Trade

	Nom. Income	PCE Deflator	Real Output	FTEs WT	FTEs RT	FTEs RT Adjust.	Hours Proxy	Multimerch. Shop.	Warehse	Capital Comb.	Labor Prod.	TFP
Levels												
1929	13511	55.3	244.32	1631	4215	4215	5846	13.95	16.499			
1941	17411	48.7	357.52	1952	5075	5075	7027	13.318	14.946			
1948	41674	82.3	506.37	2428	6477	6084	8512	12.822	14.053			
Growth rates												
1929-41			0.0317				0.0153	-0.0039	-0.0082	-0.0057	0.0164	**0.0227**
1941-48			0.0497				0.0274	-0.0054	-0.0088	-0.0068	0.0223	**0.0326**

Sources: US Department of Commerce, 1966
BEA NIPA Table 6.5A; Fixed Asset Tables 2.1 and 2.2
HSUS series BA
4580
See text for full discussion.

Table 3
Productivity Growth in US Railroads

	Output	Hours	Capital	Labor Prod	TFP
Levels					
1929	100	100	100		100
1941	105.5	68.6	94.5		141.8
1948	141.8	79.4	93.9		169.6
1950	128.6	63.5	95.6		184.8
Growth rates					
1929-41	0.0045	-0.0314	-0.0047	0.0359	**0.0291**
1941-48	0.0422	0.0209	-0.0009	0.0214	**0.0256**
1941-50	0.0220	-0.0086	0.0013	0.0306	**0.0294**

Source: Kendrick, 1961, table G-3, p. 545.

Table 4
Productivity Growth in Trucking and Warehousing

	Output	Employment	Capital	Labor Prod	TFP
Levels					
1929	10.4	56.9	6.258		
1942	74.5	89.7	6.484		
1948	123.9	107.2	11.918		
1950	174.2	129.7	14.054		
Growth rates					
1929-42	0.1515	0.0350	0.0027	0.1164	**0.1261**
1942-48	0.0848	0.0297	0.1015	0.0551	**0.0336**
1942-50	0.1062	0.0461	0.0967	0.0601	**0.0449**

Sources: Output and Employment from Kendrick, 1961, table G-VIII, p. 553.
Capital from BEA FAT 2.2, line 19, trucks, busses, and light trailers.
See also Field 2011, table 2.6, p. 51.
Note that labor input is employment, not FTEs or hours.

Table 5
Productivity Growth in Electric and Gas Utilities

Electric

	Output	Hours	Capital	LP	TFP
Levels					
1929	100	100	100		100
1941	186.5	82.5	107.8		194.7
1948	314.8	95.7	116.3		293.7
Rates of Growth					
1929-41	0.0519	-0.0160	0.0063	0.0680	**0.0555**
1941-48	0.0748	0.0212	0.0108	0.0536	**0.0587**

Natural Gas

	Output	Hours	Capital	LP	TFP
Levels					
1929	100	100	100		100
1941	163.6	91.6	110.3		164.6
1948	321.3	138.6	128.7		241
Rates of Growth					
1929-41	0.0410	-0.0073	0.0082	0.0483	**0.0415**
1941-48	0.0964	0.0592	0.0220	0.0373	**0.0545**

	Manhours 1929
Electric	756
Natural Gas	231
Manufactured Gas	172

Electric share	0.6523
Gas Share	0.3477

1941-48 Weighted Average TFP Growth:
0.0572

Sources: Kendrick, 1961, table H-VIII, H-IX, H-X, pp. 592-98.

Table 6
Productivity Growth in Mining

	Output	Hours	Capital	LP	TFP
Levels					
1929	100	100	27.435		
1941	106.5	77	26.989		
1948	133.3	88.9	35.147		
Rates of Growth					
1929-41	0.0052	-0.0218	-0.0014	0.0270	**0.0209**
1941-48	0.0321	0.0205	0.0377	0.0115	**0.0064**

Sources:
Output and Hours: Kendrick, 1961, table C-2, p. 397.
Capital: BEA FAT table 2.2, line 30, mining and oilfield equipment.

Table 7
Productivity Growth in Construction

	Nominal income	Deflator	Real Output	FTEs	Capital	LP	TFP
Levels							
1929	3835	37.6	102.0	1484	7.711		
1941	4219	38.6	109.3	1774	8.553		
1948	10612	76.7	138.4	2278	19.699		
Rates of Growth							
1929-41			0.0058	0.0149	0.0086	-0.0091	**-0.0072**
1941-48			0.0337	0.0357	0.1192	-0.0020	**-0.0271**

Sources:
Nominal Income: US Department of Commerce, 1966, table 1.12
Deflator for Total Structures: US Department of Commerce, 1966, table 8.7, p. 165
FTEs: US Department of Commerce, 1966, table 6.4.
Capital: BEA FAT table 2.2, line 29, Construction Machinery

Table 8
Sectoral Contributions to TFP Growth within the U.S. Private Nonfarm Economy, 1941-48

	1941 Nominal Income (billion $)	1941 PNE Share Nominal Income	1948 Nominal Income (billion $)	1948 PNE Share Nominal Income	1941-48 Sector TFP Growth	1941-48 Percentage Point Contrib. to PNE TFP
All Industries	104.2		224.2			
Less Agriculture, Forestry, Fisheries and Government	85.3		182.8			
Manufacturing	33.2	0.389	67.6	0.371	-0.0055	-0.0021
Wholesale and Retail Trade	17.4	0.204	41.7	0.229	0.0326	0.0071
Railroads	3.8	0.044	7.1	0.039	0.0256	0.0011
Trucking and Warehousing	1.0	0.012	2.3	0.013	0.0336	0.0004
Telephone and Telegraph	1.1	0.013	2.8	0.015	0.0181	0.0003
Electric and Gas Utilities	2.1	0.024	3.7	0.020	0.0572	0.0013
Mining	2.4	0.028	5.4	0.030	0.0064	0.0002
Construction	4.2	0.049	10.6	0.058	-0.0271	-0.0015
TOTAL of Above	65.2	0.764	141.2	0.775		0.0069
Residual Services						
FIRE	9.3	0.109	18.4	0.101		
Other transport services	1.5	0.018	3.5	0.019		
Services n.e.c.	8.9	0.104	19.5	0.107		
TOTAL Residual Services	19.6	0.230	41.4	0.227	0.0265	0.0060
TOTAL PNE		0.995		1.002		0.0129

Sources: Share of private nonfarm economy: US Department of Commerce, 1966, table 1.12
Sector share = average of 1948 and 1941 nominal income in sector divided by income in all sectors less government and agriculture, forestry, and fisheries
Sectoral TFP Growth: see tables 1-7. PNE TFP Growth: Kendrick, 1961, table A-XXIII.

Table 9

	Total Factor Productivity Growth in US Manufacturing, 1919-2015 (percent per year)	Source
1919-1929	5.12	Kendrick (1961), table D-1, p. 464.
1929-1941	3.25	See table 1, text.
1941-1948	-.55	See table 1, text.
1949-1973	1.49	U.S. Bureau of Labor Statistics (2004), table 2
1973-1995	.68	U.S. Bureau of Labor Statistics (2004), table 2
1995-2005	1.78	www.bls.gov, accessed 9/28/2017
2005-2015	-.12	www.bls.gov, accessed 9/28/2017