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THE PARADOX OF PLANNING:
THE CONTROLLED MATERIALS PLAN OF WORLD WAR II

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ABSTRACT

According to most standard accounts of the mobilization of the U.S. economy in World War II, things started out badly because the agency nominally in charge, the War Production Board, lacked sufficient authority and relied on faulty techniques. But then the War Production Board installed the famous Controlled Materials Plan, a form of central planning, which solved the major problems and turned disaster into triumph. Here we re-examine the Plan and argue that it was too little and too late to account for the success of the mobilization. As an alternative we argue that the delay in the flow of munitions may simply have been the inevitable result of time-to-build and that a good deal of coordination happened through the market. The appropriate historical analogy may not be form of European central planning, but rather the American gold rush of 1849.

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1. The Traditional Assessment of the Mobilization[1]

The conventional description of the mobilization is that it got off to a slow start, but in the end it was a brilliant success. At its peak the United States was producing considerably more munitions than Germany, the U.K., and the Soviet Union combined, probably more than the rest of the world combined (Harrison 1988). The most exciting part of the conventional view, however, is not how it happened, but why it happened. The conventional view is that a crucial breakthrough occurred when the United States abandoned a market-based approach to munitions production and adopted a form of central planning. More specifically the breakthrough occurred when the government created the War Production Board (hereafter the WPB), brought in Ferdinand Eberstadt to shake things up (although he was never made the chief executive as he should have been) who installed the Controlled Materials Plan (hereafter the CMP) which finally solved the problem of allocating scarce resources to their most productive uses.[2]

[1]We are indebted to Michael Bordo, Michel Edelstein, Stanley Engerman, Stefano Fenoaltea, Robert Higgs, and Eugene White for comments on an earlier draft. We also learned a great deal when from a presentation to the Development of the American Economy section of the NBER in July 1995 and at seminars at the University of Maryland, Harvard, and Yale. Most recently it benefitted from comments made at a conference on the economics of World War II held at the University of Mannheim which was organized in the summer of 2008 by Jonas Scherner and Jacob Streb. Hopefully the quality of this draft will reflect not only the quality of the scholars who commented on the previous draft, but also the time between revisions!

[2] Eberstadt is the hero in most narratives of the mobilization. Robert R. Nathan, an economist, who served as chair of the War Production Board's planning committee, has also garnered praise in a supporting role. He is said to have pressed for an early end to the production of consumer durables. It is also said that he liked to drive around Washington on Sundays in a red Pontiac convertible and heckle slow moving trucks, presumably to speed up the war effort. (Obituary, *New York Times*, Monday, September 10, 2001.)

The most influential account of the mobilization by far is Eliot Janeway's (1951) *The Struggle for Survival*. For Janeway (1951, 316), the CMP was no less than the masterstroke that won the war:

> "It [the CMP] quickly balanced the input of economy energy and the output of fire power. In 1942 the war economy produced something over $30 billions of finished munitions. In 1943, at virtually the same price level, munitions production fell just short of $60 billion … CMP flooded the fighting fronts with firepower."

Janeway's early enthusiasm for the CMP was endorsed by subsequent historians of the war. R. Elberton Smith's normally restrained official history, *The Army and Economic Mobilization* (1959, 568), rises to Janeway like heights when he describes the CMP: "Just as D Day was later to represent the supreme Allied effort on the military front, so the launching of CMP represented the supreme effort on the war production front". Alan S. Milward (1977, 123-24), writes somewhat more cautiously: "The central priority decisions were only made effective by the introduction of the Controlled Materials Plan." But he goes on to illustrate the point by suggesting that there would not have been enough steel for landing craft had it not been for the CMP (Milward 1977, 123-24). William L. O'Neill in *Democracy at War*, a sophisticated and wide ranging general history of the war, is almost as enthusiastic as Janeway: "Little known at the time and quickly forgotten, CMP was critical to the entire war effort" (O'Neill 1993, 91). Arthur Herman's recent book, *Freedom's forge: How American business produced victory in World War II*, stresses the contribution of American business to the war effort, nevertheless (2012, Kindle location 4044) tells us that the CMP solved an important problem by matching the supply of raw materials "directly to orders from the War and Navy departments."

Although we haven't surveyed the history textbooks systematically, the ones that we have looked at sing the praises of wartime planning and the CMP. For example, Current, Freidel, and Brownlee (1976, 308) is quite specific.

> As late as the summer of 1942, bottlenecks were halting some assembly lines. On July 4 the vital shipbuilding program had to be cut back because of scarcities of raw materials like steel plate and glass, and of components like valves, turbines, and engines. The WPB eventually broke most of the bottlenecks through the Controlled Materials Plan, which established a balanced production of finished products and allocated precise quantities of raw materials to each manufacturer.

Faragher et al. (1995, 493) tells students that "the speed with which wartime production accelerate could [in addition to America's abundant resources] be attributed to the massive reorientation and management of the economy by new government agencies."[3] In short, while there are a few dissenting voices – notably Harris (1945, 285) who thought that the Controlled Materials Plan had been oversold, and a few moderate voices such as Koistinen (2004, 326) who sees it as of "great importance" as part of a larger whole – most historians have seen it as the masterstroke that won the war. To be honest, we could cite (Rockoff 1984, 115) as part of the mistaken majority.

To put the matter in a longer time frame, we can turn to William H. McNeill's the *Pursuit of Power* (1982). This grand survey of world history sees the economics of war in the twentieth century returning to the command model, after greater or lesser reliance for 1,000 years on the market. After taking note of the early "quarrels over the allocation of scarce resources and raw materials" (McNeill 1982, 355) reports that "the end result was a spectacular increase in American output of war materiel, and of the other goods needed to supplement British, Russian, and other Allied economies as well." The explanation:

[3] The most extreme statement on the effectiveness of the Controlled Materials Plan that wehave found, is understandably, in a biography of Eberstadt (Perez and Willet 1989): "Eberstadt's Plan, put into operation by Roosevelt on November 2, 1942 created a miracle of production that broke up the major bottlenecks in little more than a month and flooded the fighting fronts with firepower."

"The kind of scheduling required to keep a complicated assembly line running smoothly in a great factory was, in effect, applied to the entire national economy of the United States."

Despite this outpouring of enthusiasm for the CMP, however, wewill argue in the balance of the paper that this view is mistaken for two reasons. (1) Far from being an attempt to increase centralized regulation and control of the economy the CMP was an attempt to liberate it from excessive regulation. (2) There is little empirical evidence that the CMP influenced the course of munitions production much in any direction. By the time it went into effect the United States was already beginning to cutback munitions production. Before delving into the CMP in detail, however, we need to review the evolution of production controls up to the time when the CMP was introduced.

2. From the War Resources Board to the Controlled Materials Plan[4]

During the interwar period Bernard Baruch had argued for a command system for organizing a war economy. The price system should be jettisoned (prices should be frozen) and decisions about how resources are allocated should be made by a single all-powerful government bureau on the basis of priorities set by the bureau. The bureau should be headed by one masterful executive (Baruch?!) who should be granted whatever power it took to get the job done. Baruch saw this as the clear lesson to be drawn from the experience of the War Industries Board that Baruch headed in World War I; New Dealers saw it as the logical implication of the failure of capitalism revealed by the Depression; and it struck a responsive chord in the media and in the general public who

[4]The basic facts chronicled in this section are available in a number of sources including The United States, Bureau of the Budget (1972 [1946]).

felt that if there was an important job to be done someone should be “in charge”. This theory of how mobilization should be done hung in the background, but until there was a declaration of war, Roosevelt could take only slow and halting steps.

The first step was taken in August 1939 when Roosevelt created the War Resources Board to survey the nation's resources and to suggest a plan for mobilizing them. Edward Stettinius, Jr. from United States Steel headed a board composed of businessmen. The Board immediately and predictably drew the fire of liberals, agriculture, and labor all of whom wanted to be represented. The Board wrote a report, for Roosevelt's eyes only, that claimed that America had abundant resources to meet any conflict – expansion of capacities in steel and aluminium, for example, were not needed – but recommended that in the event of U.S. involvement, mobilization be entrusted to an all powerful bureaucracy along the lines suggested by Baruch. This wasn't what Roosevelt wanted to hear. In November 1939, the Board was dissolved, its members were thanked, and its Report was filed, to be made public after the war.

In May 1940 Roosevelt established the National Defence Advisory Commission. It included William S. Knudsen, President of General Motors, Sidney Hillman, of the United Ladies Garment Workers, and representatives of other interest groups. Its purpose was to expedite the awarding of contracts for munitions and to plan future policies. The member of the Commission, although nominally advisors, quickly built up staffs that became the nucleus of subsequent agencies. The deteriorating situation in Europe increased the pressure on Roosevelt to create a more powerful agency. In November 1940 he created the Office of Production Management, which began operations in January 1941, taking over the functions and personnel of the National Defence Advisory

Committee. Roosevelt stoutly resisted pressures to appoint a single executive to head the agency insisting that there was no need for a "Poobah, Czar, or Akoond of Swat." Instead he appointed Knudsen as Director-General and Hillman as Associate Director–General – insisting that the question of who was the head man was irrelevant.

The most important problem that the new agency faced was the priority system (Koistinen 2004, 175-190, 204-06, 314-17). In theory the system was very simple. A government agency – the Army-Navy Munitions Board, the new Office of Production Management, or another agency – would rate contracts according to their importance for the war effort. Manufacturers were required to complete higher rated contracts first, tanks before toasters. But the system was rapidly becoming clogged with high priority contracts, the beginning of "priorities inflation," a problem that would dog the priority system for the remainder of the time it was used.

What was priorities inflation? Initially, priority ratings consisted of three letters A, B, and C each divided into 10 numerical bands, A-1, A-2 … A-10, and so on. A-1 priority projects had to be completed before A-2 projects and so on. One problem was the understandable tendency for a bureaucrat to award an A-1 priority to all of the contracts coming across his desk, thus avoiding any blame if a project was not completed on time. Prime contractors, moreover, were permitted to place ratings on subcontracts. In theory the rating on the subcontract would reflect the rating on the prime contract. But again the natural tendency was to place an A-1 rating on every subcontract. The A-1 rating quickly became merely a "hunting license" for materials. In November 1941 the A-1 rating was broken into A-1-a through A-1-j. Later, still higher ratings were added. Eventually, the system stabilized with ratings of AAA through A-1 … A-4. The stabilization reflected the abundance of raw materials during most of the time when the final set of priorities was used.

In August 1941, in the midst of the priority crisis, Roosevelt created the Supply Priorities and Allocation Board. This Board brought together representatives of the various agencies issuing priorities including the Army-Navy Munitions Board and the Office of Production Management, to set, hopefully, an overall policy. Donald Nelson, a Sears executive (from the purchasing side) who was working for the Office of Production Management, was made executive director. The administrative structure of the agency was heavily criticized at the time: Knudsen was a member of the Supply Priorities Allocation Board and in that capacity superior to Nelson whose job was to implement the Board’s decisions; but Nelson then gave orders to the Office of Production Management, thus making him, in that capacity, superior to Knudsen!

Pearl Harbor (and the continuing problem of priorities inflation) led to the establishment of the WPB in January 1942 with Nelson becoming the sole director. The press greeted the new organization enthusiastically: at last someone was "in charge." In the next few months Nelson reached "concordats" with the Army and Navy that ceded to them the right to place orders for munitions without prior approval by the WPB. There may well have been little else he could do. The WPB did not have a bureaucracy in place that could evaluate the enormous number of contracts that was flowing from the military. But the crucial tool for controlling production thus passed from Nelson's hands, to be regained only partially and with difficulty.

Nelson's honeymoon with the press was short lived. Munitions production was below expectations, small business was angry about a system that seemed to be giving all the contracts to big business, and the priorities mess was growing worse. By the spring of 1942 it was clear that the priorities system was broken and needed to be replaced.

The first attempt to replace the priorities system was the Production Requirements Plan. Under this plan manufacturers would file detailed reports with the WPB showing their contracts (including preference ratings), and their inventories of raw materials. The WPB then would decide on the amount of raw materials the manufacturer was allowed to buy, and the preferences ratings that it could assign to those purchase contracts. The Production Requirements Plan still made use of priorities, but it promised improvement along two lines. First, it took the power to issue priorities for raw materials away from prime contractors (one of the sources of priorities inflation) and secondly, it created a flow of information from which the WPB might compute aggregate supplies and demands.

Despite high hopes for it, however, the Production Requirements Plan turned out to be a disappointment. Novick, Anshen, and Truppner (1949, 19-135) attribute the difficulties to the inadequacy of the bureaucracy set up to administer the Plan – the bureaucracy wasn't big enough and wasn't given enough time to get organized – and to opposition to the Plan from elements within the WPB. In August 1941 Ferdinand Eberstadt, an investment banker during peacetime with considerable experience in government, and the hero of most accounts of the mobilization, was brought from the Army-Navy Munitions Board to the WPB. He immediately went to work on the CMP.

3. The Controlled Materials Plan

The CMP, although complicated in detail, was essentially a system for rationing three important raw materials: steel, copper, and aluminium. The system, although modified over time, went ahead for the most part according to an outline issued in November 1942 when the plan was announced (U.S. War Production Board 1942). The idea was relatively straightforward, at least in comparison with earlier plans. (1) Each "claimant agency" was to submit estimates of its requirements for controlled materials to the WPB. Initially, there were seven claimant agencies: the War Department, Navy, Maritime Commission, Aircraft Scheduling Unit, Office of Lend Lease Administration, Board of Economic Warfare, and the Office of Civilian Supplies. (2) The WPB would then evaluate these estimates in the light of the WPB's estimates of existing supplies. (3) The Requirements Committee of the WPB would then decide on monthly allotments of controlled materials for each of the claimant agencies. (4) The claimant agencies would then be notified of their allotments to which they would have to adjust their programs. (5) Each claimant agency would then divide its allotments among its major contractors. Each sub-allotment would be accompanied by an allotment number, in effect a ration ticket, showing the program and month. (6) These allotment numbers would then move from contractors to subcontractors, accompanying orders for raw materials, eventually reaching the mills where they would be honored. (7) The mills would then report their shipments to the WPB. (8) Cheaters were guilty of a criminal act, and subject to a $10,000 fine, a year in prison, or both.

All of this applied to "A" products, those manufactured by major government contractors and their subcontractors who were typically closely tied to one claimant agency. It was recognized that some manufacturers sold products, sometimes in small quantities, to a wide range of firms on the open market. Producers of these "B" products could get their allotments directly from the WPB. A substantial period was allowed for the WPB, the other agencies involved, and for industry to prepare for the expected volume of paperwork. The plan went into operation on a trial basis in April 1943 and on a compulsory basis in July.

Why did it take so long to get the Plan going? After all, it would be mid-1943 before the Plan was finally in operation. The files labelled “Controlled Materials Plan” in the Eberstadt papers (Princeton) may contain a clue: They deal almost exclusively with staffing. It was evidently extremely hard to find people experienced with materials control who were willing to go to Washington on a full time basis. Reading these files, one can see how difficult it was to put together the team that would actually administer the Plan.

The CMP was, as the preceding history should make clear, a retreat on several fronts from the attempts at micro-managing production that preceded it. The CMP was restricted to three materials, steel, copper, and aluminium; the Production Requirements Plan that preceded it was based on a much longer list of materials, including a long list of chemicals. The CMP left decisions about how much major contractors would get to the claimant agencies, and how much subcontractors would get to the major contractors; the Production Requirements Plan centralized these decisions in the WPB. In principle, moreover, the CMP specifically excluded attempts to expedite the supply of controlled materials to individual projects (Novick, Anshen, Truppner (1949, 170)). Thus, the CMP was not the final stage in a process of ever more detailed central planning; it was really the opposite, an acknowledgement that detailed planning was unworkable.

Why was the CMP expected to have dramatic effects? In the first place it was expected to have the usual positive effects of rationing when prices are fixed: reducing hoarding, saving the resources spent searching the market for supplies, bribing suppliers, and so on; in general ending the mad scramble for raw materials. The hope was that the effects would extend far beyond the controlled materials. The basic problem in the mobilization – the cause of many of the examples of wasted resources identified by critics – was believed to be the excessive demands being placed on the economy, what was known as the "feasibility problem." It may have been first identified in a March 1942 memo written by Simon Kuznets (Edelstein 2001). The CMP would attack the feasibility problem because demands for uncontrolled materials and labor would be scaled back when claimant agencies scaled back programs to make them consistent with allocations of controlled materials.

Table 1 explains how the CMP worked. The table shows the estimated supply of raw materials (which turned out to be quite close to the amount produced), the amount requested by claimant agencies, the amount allocated to claimant agencies (budget allotment balance), and the amount allocated by claimant agencies to prime consumers (allotments issued to prime consumers), typically major defence contractors. Stated requirements of the claimant agencies always exceeded expected supplies. In the fourth quarter, for example, stated requirements for carbon steel (the amount the claimant agencies said they needed) was 19.599 million short tons, exceeding supply, as it was then estimated, by 27.5 percent. This was to be expected for two reasons. First, the purpose of the CMP was to force cutbacks in what were viewed as overly ambitious programs. Second, claimant agencies naturally overstated their needs in order to get as large an allotment as possible after the expected cuts imposed by the WPB. In the case of carbon steel in the fourth quarter the WPB allocated only 16.898 million short tons, about 85 percent of what had been asked.[5]

The most surprising aspect of Table 1 is that the quantities allocated to claimant agencies exceeded by substantial amounts the quantities reallocated to prime consumers. In the third quarter, for example, only 93.2 percent of the carbon steel allocated to claimant agencies was reallocated. In some cases allotments to prime consumers even turned out to be less than the available supply – copper and copper-base alloys in the third quarter and capper and aluminium in the fourth quarter. This phenomenon was referred to as "allotment attrition." In the third quarter *Controller's Report* it was treated as a surprising, possibly alarming development. It appears, moreover, although no figures are available, that attrition was the rule throughout the production process: Quantities allocated to prime consumers in turn exceeded orders placed against metal mills and orders placed against mills exceeded shipments.

Smith (1959, 590) offers a number of reasons for attrition: (1) overstatement of requirements, (2) reductions in requirements after the issue of allotments, (3) hoarding as emergency reserves, and (4) exploitation of alternative sources of controlled materials (Smith 1959, 590; Goldstein 1946, 39-40).[6] Only (3) is consistent with shortages of controlled materials. The value of a ration ticket depends on the amount of excess demand. The tendency of the allotment numbers to get lost along the way, especially for reasons such as (1), (2), and (4), shows that they weren't very valuable, and therefore that

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[5]This amount still exceeded the estimated supply by a substantial amount, 9.9 percent. It is not clear why the WPB chose to allocate more carbon steel that it thought would be produced. The *Controller's report* suggests that the purpose was to pressure the mills to maintain maximum production.

[6]Goldstein (1946, 39-40) notes that "past-due unfilled orders [for aluminum] showed no substantial change" under the CMP. If CMP broke bottlenecks in production, we would expect this number to decline.

supplies of and demands for controlled materials were close to being in balance at official prices.

Production figures confirm that supplies of controlled materials were abundant by the time the CMP was put in place. In fact steel production peaked in March 1944, eight months after the CMP became mandatory; aluminium production peaked in October 1943, only three months after the CMP became mandatory; and copper production peaked in June 1943, while the CMP was being put in place (Dewhurst & Twentieth Century Fund 1947, 778). Production fell simply because of cutbacks in orders; mill capacity was more than adequate. The official history of the WPB's steel division's experience with the CMP notes that mill capacity for ferroalloy steel exceeded orders placed throughout the CMP period (Hunter and Hogan 1950, 78). In other words, the main problem the CMP was created to deal with, excess demands for some of the crucial raw materials had largely been resolved by the time the CMP went into operation.

During the time that the CMP was being put in place tensions between Nelson and Eberstadt, and more fundamentally between Nelson and the military, had been growing (Koistinen 2004, 334). According to Nelson the differences were technical: Eberstadt wanted the WPB to focus on materials allocation; Nelson wanted the WPB to focus on the scheduling of production, a job for which Nelson brought in Charles Wilson of General Electric. Nelson may also have felt that Eberstadt was a potential rival. By February 1943, after the announcement of the CMP but before it went into effect, criticism of Nelson reached a climax. Roosevelt finally decided to resolve the controversy by replacing Nelson with Baruch. But Nelson got wind of the threat, and hours before Roosevelt was set to offer the job to Baruch (by one account) Nelson fired

Eberstadt and announced it to the press. Roosevelt, unwilling to side publicly with Baruch and the military (recall that Eberstadt had started with the military), kept Nelson on at the WPB. Thus, Eberstadt was fired before the plan which made him famous went into effect.

Some historians have assumed that Nelson was concerned solely with defending his turf and have given short shrift to his criticism of the CMP. The assumption concerning Nelson's motives may be correct, but that doesn't automatically invalidate his criticism. In fact, what he has to say about the CMP (Nelson 1946, 383-84) is consistent with the allotment attrition revealed in the controller's reports "by the time requests came in for materials under the CMP the contracts had been let and the manufacturers were in the market actively seeking supplies. Control simply could not be exercised at the CMP level."

4. The Controlled Materials Plan and the Output of Munitions

Ultimately, the claim that the CMP was the key to solving war production problems and maximizing production must be tested by data on war output. Recall Janeway's iconic claim that CMP "flooded the fighting fronts with firepower." Evidence that paperwork moved more efficiently through the system, or even that administrators felt better about what they were doing, would be interesting, but the test of the CMP is whether it increased production or saved raw materials. Measuring war output, however, involves some vexing index number problems. The basket of goods produced during the war differed profoundly from what had been produced before the war and what would be produced afterwards. Technological progress, moreover, was rapid during the war because improvements resulting from scientific advances or battlefield experience were rapidly fed into arms production.[7]

For a market economy we can solve analogous measurement problems by using prices. Amounts of automobiles, telephones, and apples can be added by using their market values. The value of technological improvements can measured (sometimes) by how much the market is willing to pay for them. The pricing of most war output, however, took place under circumstances that raise serious questions about using delivery prices of tanks, bombers, and submarines to produce price indexes of war output.[8] Many contracts were let on a "cost-plus" basis so that the delivery prices in military contracts represented a small fraction of the resources transferred to contractors (Higgs 1993). Technological progress occurred so rapidly, moreover, that carrying prices forward from the prewar era or carrying them back from the postwar era, when they might have been more like market prices, would be of questionable value.

Table 2 shows several annual series on war production. The first set of estimates was computed by the WPB and is closely related to their indexes of the physical production of munitions that will be analyzed below. The second set was computed by Kuznets in order to examine pricing problems in the war sector. Kuznets's estimates will also be analyzed in more detail below. The third set of estimates was made by John Kendrick. Kuznets believed that productivity was initially low in the munitions industry compared with long-established peacetime industries, but then caught up rapidly. This is

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[7]Measured by the ability to defeat enemy weapons, technological progress was slower because improvements in weapons – thicker armor on tanks, faster speeds for aircraft, and so on – often merely offset improvements in the enemy's weapons.

[8]Serious questions have also been raised about using civilian prices during the war to aggregate civilian output. (Higgs 1992) is the most skeptical.

why his estimate of gross war production at constant 1943 factor prices disregarding possible inefficiencies in munitions production (row 3) is close to the WPB's estimate of a similar concept (row 2) in 1942 and 1943, but his estimate of gross war production adjusted for inefficiency in the munitions industry is 40 percent below the WPB's estimates in those years.

Nevertheless, while Kuznets's concern is well taken, the various series agree that there was a substantial increase in production between 1942 and 1943. The WPB's index of total munitions (line 1) grew from 31.6 billion in 1942 to 56.4 billion at constant prices, a factor of 1.78. Kuznets's estimate of gross war output at final product prices after adjusting for efficiency (line 4) increased from 28.7 billion to 48.2 billion, a factor of 1.68. Kendrick's estimate of National Security expenditures at constant prices (line 5) rose from $51.7 billion in 1942 to $80.4 billion in 1943, a factor of 1.56. These figures are the heart of Janeway's argument that the CMP "flooded the fighting fronts with firepower:" Production rose dramatically between 1942 without the CMP and 1943 with it. The problem with Janeway's argument is its reliance on *annual* data to analyze a rapidly evolving process. We need monthly or at least quarterly data. Fortunately, two adequate sets of data are available: the WPB's monthly index of the physical volume of munitions production, and Kuznets's quarterly estimates of net war output.

4. A. The CMP and the Physical Volume of Munitions

The War Production Board computed a monthly index of the total physical volume of munitions and six sub-indexes. They were published regularly (with a lag) in the *Survey of Current Business*. Copeland, Jacobson, and Lasken (1945) describe how the indices were computed. The key decision was to use a set of fixed prices (usually August 1943) to weight physical quantities. The indexes cover not only procurement by the military services, but also procurement by the War Shipping Administration, and by the Allies. Figure 1 shows the index of total munitions production and vertical lines for the month in which the CMP was introduced on a voluntary basis (April 1943) and the month when it became mandatory (July 1943). The story now appears very different from the one suggested by the conventional assessment of the CMP based on annual data. Total munitions production was already close to (86 percent of) its wartime maximum when the CMP became mandatory. Given the rapid rate of increase in munitions production up to July 1943 it is hard to believe that the economy could not have come close to its maximum even if the CMP had never been introduced. Indeed, by the time the CMP became mandatory, it was clear that munitions production was or soon would be more than sufficient to produce all that was needed for victory: cutbacks were in the offing.

The component indexes of the munitions index show some interesting variations on the basic theme. This can be seen in Figure 2 which plots the seven component indexes computed by the WPB: aircraft, ships, guns, ammunition, combat and motor vehicles, communication and other electronic equipment, and other. The overall picture is a drive for maximum production that peaked for most series in late 1943. Two series, however, peak later: aircraft (March 1944) and ammunition (January 1945). It is unlikely, however, that the late peaks in these series were the result of a reallocation of scarce materials made possible by the CMP. For one thing supplies of copper and aluminium, materials important for aircraft and ammunition were relatively abundant. Loss of aircraft from enemy action was high as the bombers penetrated closer and closer to the hearts of Germany and Japan. And the rapid pace of technological progress meant that models built early in the war became obsolete and had to be replaced by new models incorporating the latest developments. The late peak in the ammunition series reflects the relatively late involvement of the United States in heavy fighting in Europe, the German counteroffensive (the battle of the bulge that began in December 1944) and an underestimate of the willingness of the Germans and the Japanese to resist until the bitter end.

4. B. Kuznets's Estimates of War Output

Kuznets provides what is still one of the best treatments of the problems in measuring output in a war economy in *National Product in Wartime* (1945). There he discusses some of the larger philosophical issues inherent in defining "final product" in a war economy as well as the technical index number problems. Kuznets's solution to the these problems is ultimately straightforward. He develops estimates of the level of efficiency in war industries relative to comparable nonwar industries in 1939. His estimates make war industries only about 75 percent as efficient as comparable nonwar industries in the first half of 1943. A tank factory in 1943, to give a concrete example, might have been only 75 percent as efficient as a farm-tractor factory in 1939 because the latter had a much longer time to work out the efficient way of doing things. The estimates of relative efficiency are then combined with factor prices to produce indexes of final product price for war goods. Kuznets's adjusted estimates of net national war output are based on numerous conjectures which he explains. Nevertheless, it brings us closer to the truth to recognize that the pricing problem exists and then make whatever adjustments for it we can.

Kuznets's preferred estimates of real net war output and the unadjusted estimates are plotted in Figure 3. Kuznets constructed several variants, but they all lay between these two lines. As before, the graph contains vertical lines showing the voluntary and compulsory starting dates for the CMP. And as before the figure shows that real net war output was already levelling off by the time the CMP was put in place. Kuznets's estimates of real net war output increase only 2.3 percent between the second quarter of 1943 and the fourth quarter.

4. C. Formal Tests for Structural Breaks

It is obvious from inspection of the data that there are breaks in trend in the various time series depicted in Figure 2. The object of this section is to formally test for breaks and to determine the nature of each break. That is to determine if the break is a change from low to high growth or a change from high growth to low growth in each of the time series. It appears from inspection of the data that there are at least two major breaks in trend in most of the series. This provides some complication as most easily applied tests address the case of only one break in the data. In order to handle the possibility of more than one break we use the following strategy: first we break the data into two parts and use the tests for a single break on each of the two subsamples separately. Second we apply a test that is valid for multiple breaks on the whole sample. Our findings are consistent across both types of tests.

Our strategy is as follows: First we test for the presence of unit roots in our time series. We do so using tests that are robust to structural breaks and, if it is the case that there is not a structural break present in the data, a test that is robust to heteroskedasticity.

We employ the unit root test outlined by Zivot and Andrews (2002) for each of our sub-samples.[9] As an alternative we also employ the unit root test of Elliott, Rothenberg, and Stock (1996) (ERS) which has power in the presence of heteroskedasticity. The results of these unit root tests can be found in Table 3. In this table we report the test statistic for each test and for each sub-sample and in the case of the Zivot and Andrews test we also report the date of the structural break found by the test. The two sub-samples employed are overlapping (in order to get as large a sample as possible) with the first sub-sample starting in July of 1940 and ending in April of 1943. The second sub-sample starts in January of 1942 and ends in December of 1944. Both of these sub-samples are chosen so that there is at most one "visually" identified structural break in each sample.

The results of the tests are that we cannot reject the null hypothesis of a unit root for all of the time series with the exception of the "Ammunition" sub-series. The Zivot-Andrews unit root test finds a structural break in late 1941 or early 1942 for all series in the first sub-period. In fact January 1942 is the date chosen for all series except for the "communication" and "other" sub-series. Obviously, the war effort changed dramatically with Pearl Harbor. For the second sub-period the Zivot-Andrews test identifies breaks for all sub-series but in this case the break-dates are not closely bunched together. The dates range from August 1942 to March 1944. Most break dates, however, are found near the end of 1943 or the start of 1944.

Thus the results of our unit root tests indicate that we should look for structural breaks using the first difference of all of the sub-series with the exception of the

[9] Again we break our samples in two sub-samples with the aim of having at most one structural break in each sub-sample.

"Ammunition" sub-series. For the series in which we could not reject the unit root hypothesis we estimated the following auto-regression in first differences (AR(p)) model:

$$\Delta y_t = \theta_0 + \theta_1 \Delta y_{t-1} + \ldots + \theta_p \Delta y_{t-p} + \varepsilon_t \tag{1}$$

where the lag length is determined by minimizing the Schwarz (Bayesian) Information Criterion. The unconditional mean of Δy_t is $\theta_0 / (1-(\theta_1 + \ldots + \theta_p))$ and so we test for a break in the trend of the level of the variable by looking for a break in the unconditional mean of the first difference of the time series, Δy_t. Thus we include a shift dummy variable in equation (1) and test for the date that this shift dummy is most significant. This is the QuandtLikelihood Ratio (QLR) endogenous breakpoint test as described in Stock and Watson (2010, page 560).[10] For the case of "Ammunition" we tested for a break in trend by estimation a simple linear trend model using the QLR endogenous breakpoint test. The QLR test is designed for the case where there is at most one break in the data so again we separate out sample into two sub-samples and perform the test for a structural break on each series and each sub-period separately. The results from these tests can be found in Table 4. The results are consistently in favor for a first break in January of 1942 for all series except for the "Combat and motor vehicles" series. The latter index includes trucks that could be purchased taken directly from civilian production lines, and did not require the construction of new facilities or the whole conversion of existing facilities, so it is not completely unexpected that Pearl Harbor would not produce an immediate break in the series. The results also suggest that there is

[10] This test is a modified version of the Chow test (Chow 1960) and was first proposed by Quandt (1960). Note that we are only testing for a break in θ_0 and not in the other parameters of the model. Tests for breaks in the parameters θ_1 to θ_p were done but it was found that there were no structural breaks in these coefficients so the more simple test of only a break in the constant was performed.

a second break in all series except for the “Vehicles” series but this time the date of the break is not common to all series. The “Ammunition”, “Guns”, “Ships”, and “Total” series break in late 1943 or early 1944 while the “Aircraft” series breaks later in 1944 while the “Other” series breaks earlier in late 1942. Note that these breaks are consistent with the breaks that the Zivot-Andrews test found earlier.

A final robustness test was performed to make sure we did not miss a break by testing for a break in all series using the QLR test for the period of January 1942 until December 1943 – the period between the two breaks found so far. The results from these tests are reported in Table 5. Two series show a break in this sample; “Ammunition” in February of 1943 and “Other” in September of 1942. Thus our conclusion from this series of QLR tests is that the “Combat” series does not contain a trend-break, the “Aircraft”, “Communication”, “Ships” and “Total” series contain two trend-breaks, the first being in January of 1942 and the second being in late 1943 or early 1944, and the “Ammunition”, “Guns”, and “Other” series have three trend breaks.

As a final robustness test we then used the structural break test of Bai and Perron (2003) that allows for multiple breakpoints. The results for this test are reported in Table 6. The results of the Bai and Perron (2003) tests are consistent with the results obtained with the QLR tests except for the “Other” series. The Bai and Perron (2003) test does not find any breaks in that series whereas the QLR approach found three. All the other series the results of the two tests found similar numbers of breaks and identical break dates.

The Nature of the Trend Breaks

Using two methods we have found the dates of trend breaks in all of the series. Table 7 reports the estimated trends for each sub-period identified above. For those series that have two breaks we estimate the trend for three sub-periods, for those series with three breaks we estimate the trend for four sub-periods and for those with no breaks we estimate the trend for the whole period. For the case of the "Other" series we estimated the trend for the periods identified by the QLR test. For all series with two breaks identified we see that the trend was low but positive for the initial period, increased after January 1942, and then declined sometime in late 1943 or early 1944, depending on when the second break occurred.

For "Ammunition," the trend was positive and increased after January 1942 and was followed by a further increase in trend after February, 1943. After December 1943 there was a decrease in the trend but ammunition production was still increasing, albeit at a slower rate. For "Guns," the trend was positive early and increased sharply after January 1942. Gun production continued to increase after January 1943 but at a slower rate than the previous period. After December 1943 gun production began to fall.
The "Other" category showed increases in production throughout the whole period with an increase in the rate of production after January 1942 followed by a decrease in the rate of increase of production after September 1942.

The overall results show that production increased significantly after January 1942 and declined after the end of 1943 (except for ammunition production which only showed a decline in the rate of increase in production). For those series for which we identified a break between January 1942 and the end of 1943 only one series, ammunition, showed an increase in the rate of production during this period. Gun production and “Other” production both showed declines in the rate of production during this period. All in all, the statistical tests back up the conclusions drawn from eyeballing the quarterly and monthly data: there is no reason to think that the CMP produced a positive change in the rate of production of munitions.

4. D. Limitations and Extensions of the Timing Evidence

There are two possible objections to the timing argument that need to be considered. First, since the CMP was announced in November 1942, it is natural ask whether anticipations of the program could have had a positive impact. But this seems unlikely. The credibility of the WPB was at low ebb when the plan was announced. A *Business Week* article reporting the announcement of the CMP referred to the final plan with quotation marks around final. In these circumstances it is hard to believe that manufacturers would suddenly alter their behaviour without concrete evidence that the latest plan was going to be successful. In many cases, moreover, the incentives setup up by the announcement would have been perverse. Knowing that supplies of steel were going to be strictly rationed eight months hence, for example, would have encouraged hoarding in the interim.

A second possible objection is that the plan may have played a role in forestalling a collapse of the high rates reached in late 1943. Usually, however, we assume that once the economy has reached a high level of production it can sustain that level provided aggregate demand is adequate. Once an airplane factory has been built, for example, the workers assembled and trained, technological problems solved, sources of raw materials secured, and a high rate of production achieved, it is hard to see why that level could not be maintained provided orders for planes were forthcoming.

Although the timing evidence rules out any substantial impact on war production, it is still possible that the CMP increased efficiency of the war production sector, for example by reducing the hoarding of controlled materials. This possibility is addressed in Figure 4 which shows total munitions production relative to steel ingot production and relative to nonferrous metals production – both indexes adjusted so the monthly average for 1943 equals 100.[11] The munitions-steel ratio peaks in December 1943 after a minor spurt that might be attributed to the CMP. But even this attribution is debatable because the ratio was moving upward steadily before the CMP, and had spurted in a similar way previously. There was a more important spurt in the munitions-nonferrous-metals ratio about six months after the CMP. This spurt, however, was the result of the decision by aircraft manufacturers to run down their inventories because cutbacks in orders and favourable war news suggested that drastic cuts were in the offing (Goldstein 1946, 42). The CMP was not a factor.

There is insufficient data to compute unbroken monthly measures of labor productivity or total factor productivity in the munitions sector. From time to time, however, the government published estimates of employment. The available estimates, along with a corresponding index of productivity in munitions production, and the monthly rate of change in the index of productivity are shown in Table 8. Evidently, the main story is that labor productivity in munitions production increased rapidly until the fall of 1943 when the pace slowed. Although labor productivity made additional gains,

[11] The non-ferrous metals group included copper and aluminum, two of the controlled materials. Unfortunately, we have been unable to locate a monthly index for aluminum separately.

peaking in December 1944, there is no evidence of acceleration in the growth of productivity associated with the adoption of the CMP.

A more formal test for the possibility that the CMP accelerated the pace of mobilization is shown in Table 9. Percentage changes in the aggregate munitions series, and in the component series, were regressed on the lagged value of the natural logarithm of the number of unemployed workers and on a dummy variable that was set at one in the months following the implementation of the CMP. The point of including unemployment was to capture the rapid movement of the economy to the production possibilities curve. When unemployed resources were abundant, large gains in munitions output could be made easily: the coefficient was expected to be positive. In Table 9 only the data from January 1942 (the month following Pearl Harbor) to the month in which the series reached its peak is used. If the entire sample is used the coefficient on the dummy for the CMP picks up the cutbacks resulting from the termination of contracts and becomes negative. Using only the series up to the peak allows the coefficient to be positive. The unemployment variable is significant in the total munitions equation and in the component equations. The CMP variable, on the other hand, is insignificant in all of the equations. The coefficient, however, is positive in all of the regressions except for the aircraft regression. This can be taken as weak evidence of a positive effect, although the coefficients are not estimated with sufficient precision to say much about what that effect might have been.

5. Two Case Studies

To explore the timing and productivity issues in greater detail we can look to case studies of individual industries. Although there are many of interest, we have found two that deserve special attention because of the existence of detailed quantitative data and important qualitative industry studies: ships built by the U.S. Maritime Commission and Aircraft.

5. A. The U.S. Maritime Commission

The U.S. Maritime Commission, which built civilian transport (including the famous Liberty Ships) and some military ships, kept detailed records for every ship it produced on costs, labor hours, and related variables (Fischer 1949). This data has attracted a number of scholars interested in the sources of productivity growth. The Maritime Commission was also fortunate in its historian, Frederic Chapin Lane, whose *Ships for Victory* (1951), may well be the best history of any component of the mobilization. The Maritime Commission is also important for our purposes because it was a major user of carbon steel, one of the controlled materials, and probably the controlled material in tightest supply.

Figure 5 plots several series of interest: total output (displacement tonnage of ships worth produced), the Ships component of the WPB index of munitions, labor productivity (total output divided by labor hours), and steel in inventory (months of current consumption). For convenience in reading the figure, the series have been indexed so that 100 is the monthly average of the output series for 1943, 50 is the average for the productivity series, and 25 is the average for the inventory series. As might be expected, the output of the Maritime Commission shipyards parallels the WPB Ships index. Both series peak a few months after the CMP became mandatory. Labor productivity fell initially (because it took time for labor to learn its new skills and for ships to reach completion) but toward the end of 1942 labor productivity began to rise steadily, peaking (temporarily) at about the same time as total production. The increase in productivity between the time the CMP became mandatory and the peak was about 12 percent. So this is an upper bound on what the CMP could have added. Productivity then fell, perhaps reflecting a delay between cutbacks in production schedules and the release of personnel, before reaching a second peak in 1945. But the latter peak must have reflected, at least in part, a reorganization of the shipyards in the wake of the scramble produced by the initial drives for maximum output, as well as any effect from the CMP.

It seems likely, moreover, that the true contribution of the CMP to productivity must have been considerably less than 12 percent because the rise in productivity seems to have been mostly the result of economies of scale achieved through long production runs. This has been shown by a number of researchers who have used the data to explore learning-by-doing including Searle (1945), Rapping (1965), Thompson (2001), and Thornton and Thompson (2001). Gemery and Hogendorn (1993) documented a similar story for destroyer production. By talking with people who had worked in the shipyards they were able to discover some of the sources of economies from long production runs such as the use of standardized templates for cutting parts.

The Maritime Commission data are especially valuable because they contain information on inventories of steel. Steel inventories (measured relative to current consumption) fell to a minimum in August 1943 and this could plausibly be attributed to the CMP. Even this attribution, however, is far from clear. Inventories began dropping after May 1943 and drop may have been the result of the push to obtain maximum production. Inventories then began to rise stabilizing at levels reached in the first phases of the program. If the drop in inventories had been the result of more efficient management of reserves forced upon the shipyards by the CMP, we would expect the low levels of inventory to have continued for the remainder of the war. In any case, Lane (1951, 344) tells us that in 1944 the Maritime Commission program turned toward faster cargo and military ships and that as a result “propulsion machinery and skill in labor or management became more important as limiting factors than steel.” So at most the contribution of the CMP to ship production was limited to the third and fourth quarters of 1943.

5. B. Aircraft

Aircraft production and output per labor hour are plotted in Figure 7. The output data is indexed so the monthly average in 1934 is 100, and to make reading the graph easier, the productivity series is indexed so that the 1943 average is 50. The two series on output – the WPB index and Middleton’s (1945) index for the Department of Labor of Airframes Produced – agree reasonably well. Both peak in March 1944. The Department of Labor index was based on the weight of planes produced, which rose as production shifted toward long range bomber, and this may explain why this series rises somewhat higher, and does not fall off as fast, as the WPB series.[12]

Labor productivity in aircraft production surged strongly in 1943 and 1944. Middleton (1945, 219-220) cites a number of causes. Initially, aircraft factories hired

[12]Middleton (1945, 217) describes his index as follows: Derived from airframe weight of complete planes and spare parts accepted, divided into two categories: (1) Combat planes and heavy transports and (2) trainers, liaison planes, and light transports. The two groups were weighted by approximate average man-hours required per pound of airframe in each category.”

inexperienced workers anticipating future demands, and experienced workers spent considerable time training the new recruits, reducing measured productivity in 1942. In 1943 a number of new plants came on line, specialized in individual models, and achieving, as in the case of shipbuilding, economies from long production runs (Alchian 1963). These factors surely explain most of the growth in labor productivity in airframe production. Yet looking at the crude timing data one cannot rule out some impact on productivity from the CMP, because labor productivity continued to surge for several quarters after the CMP was mandatory.

But aircraft production, at least in part, was one of several cases in which the WPB was unable, initially, to enforce the CMP. The Aircraft Resources Control Office at Dayton, Ohio, which was responsible for allocating aluminium extruded shapes, apparently operated for a time with what Novick, Anshen, and Truppner (1949, 199) refer to as a "double set of books." As we read their account, the Control Office overstated its requirements of aluminium extruded shapes in order to get as large an allocation as possible.[13] Since stated requirements exceeded the amount allocated by the WPB (an amount based on actual production) this should have meant, according to the theory of the CMP, a cutback in planned aircraft production. But the Control office did not force the issue during the early phase of the operation of the CMP. Reported requirements and production were brought into line, according to Novick, Anshen, and Truppner (1949, 199) after two quarters, a point wehave marked on the graph, perhaps somewhat unfairly, as the end of double bookkeeping. This point was reached three months after production

[13]Novick, Truppner, and Anshen (1949, 199) in the passage cited describe the problem in only one category of aluminum. But subsequent remarks (1949, 385-86) suggest the use of "double bookkeeping" was general. The problem was also noted by Koistinen (2004, 325).

of aluminium had peaked and only two months before production of aircraft peaked. It is hard to believe, then, that the CMP had much to do with the success of the aircraft production program.

6. The Gold Rush of 1942

If the CMP does not explain the success of the mobilization, what does? More generally, and more speculatively, if "central planning" is the wrong metaphor for characterizing the American approach to mobilization, what is the right metaphor? We would suggest, tentatively, that the best way of understanding the mobilization is to see it as the great gold rush of 1942.[14] When gold was discovered in California in 1848 the favourable relationship between the price the government would pay for gold and the cost of producing it was recognized immediately. Men and women stopped plowing, unhitched their horses, and headed for California. There were shortages and overcrowding, and many people who hoped to get rich didn't. Many died trying. But in a few years a flood of gold was flowing from the stream beds and mines of California and changing economic conditions throughout the world. Something similar was true in 1942. Once the favourable relationship between the prices the government would pay for munitions, or for the factories to produce munitions, and the cost of producing them was recognized the rush was on. Corporate profits after taxes, including wartime excess profits taxes, rose about 40 percent between 1939 and 1942 (Table 10). Alcoa, for example, was criticized for not expanding capacity fast enough in the later 1930s through

[14]Viewing the mobilization as a gold rush is not a particularly new way of seeing the mobilization. The novelist and journalist John Dos Passos (1968) wrote during the war about the "Gold Rush Down South." Johnson's (1993) social history of Oakland California and the East Bay during the war is entitled *The Second Gold Rush*.

1941. But when the Defense Plant Corporation contracts were made available that provided substantial profits at little risk, Alcoa went to work building new plants. Production tripled between 1941 and 1943.

Labor, of course, responded to the availability of high wage jobs. Here is Janeway (1951, 172) on one episode.

> "At Charleston in Southern Indiana, DuPont went to work on a major powder project. Attracted by the atmosphere of boom, swarms of unskilled labor swelled the population from 800 to 5,000, to 15,000, to a mass of unabsorbed and unhoused workers spread over all the neighboring towns."

Bret Harte, who won fame for his stories about the gold rush ("The Luck of Roaring Camp"), would have recognized the scene.

As in the California gold rush it was often outsiders who were the first to take advantage of new opportunities. Richard C. Reynolds, for example, used his political connections to secure a Reconstruction Finance Corporation loan and enter aluminium refining (Smith 1988, 217). The most spectacular success was Henry Kaiser who used the war to enter shipbuilding, magnesium, steel, and aircraft production (Adams 1997).

There were, of course, important differences between the California gold rush and the war mobilization. For one thing, there were more centers of production during the war, although California was a magnet in 1942 as it had been nearly a century before. The main difference for our purposes was that in 1942 public opinion held that the mobilization ought to be centrally controlled both to assure speed and efficiency, and to ameliorate unwanted effects on the distribution of income. For that reason government became far more involved in the gold rush of 1942 than it had in the gold rush of 1849. In 1849 the government's policy of a fixed price of gold created and sustained the boom. In 1942 it was the government's willingness to finance munitions production that created and sustained the boom. There was even a parallel in the way the gold rush of 1849 and the gold rush of 1942 were financed. Gold production was financed ultimately by increases in the demand for money and by a tax on cash balances as inflation eroded the real value of existing money holdings. Similarly, munitions production was financed partly by selling bonds to the Federal Reserve creating new money that satisfied increased demands for money at current prices and created inflation.

A gold rush was not the only way of producing gold in California in 1849. One can imagine, for example, gold being produced by federal employees in nationalized mines, or by tightly regulated and coordinated private firms. And one can imagine munitions being produced in 1942 in nationalized arsenals or by tightly regulated and coordinated private firms. But this was not the way it was done in 1852 – or wewould argue, in 1942.

Although the CMP has received the bulk of the credit for the success of the mobilization, there were many other many other agencies that were attempting to speed the mobilization. The Office of Price Administration fixed consumer prices and rationed consumer goods. The National War Labor Board set wages. The Selective Service System drafted some young men and exempted others because their work was important to the war effort. And there were many other: the Foreign Economic Administration, the Rubber Reserve Company, the Petroleum Administration for War, the War Manpower Commission , the Committee for Congested War Areas, and so on. Many of these agencies undoubtedly made positive contributions to the war effort. To take one example, George Q. Flynn (1979, 69) argued that the War Manpower Commission’s “West Coast Plan” eased labor recruitment at key plants. My conjecture, however, that in many cases studies of the type conducted here would produce similar conclusions: efforts to speed the mobilization or modify the side effects through centralized controls, even when they were effective, did not reach fruition until the mobilization was well advanced.

7. Conclusions

Most accounts of the U.S. Mobilization during World War II sound similar notes. The mobilization got off to a slow start because government attempts to control the process were confused and halting. The priorities system didn't work very well, and produced priorities inflation. But then the War Production Board introduced the famous Controlled Materials Plan which saved the day by substituting central planning for the market. But a careful look at the Plan shows that it was generally a retreat from previous attempts to control the war economy in detail – a liberalization rather than ratcheting up of control. And a careful comparison of the timing of the introduction of the Plan with the monthly statistics on war output shows that it finally went into effect too late to have had a major impact on production. The point had been reached when it was time to begin cutting back on war production.

If this is so, why has the Controlled Materials Plan enjoyed a reputation as the masterstroke that won the war? For liberal historians, hopeful of finding examples of successful government intervention in the economy, a government policy introduced with ideologically resonant terms such as "controlled," "materials," and "plan" may have been too much to resist. But even Lionel Robbins (1956, 202-25) thought that the private sector simply could not respond with sufficient speed and singleness of purpose to get the job done in time. Perhaps as a British economist he was less familiar with examples, such as the great gold rushes of the nineteenth century, when profit incentives made things happen quickly. But the most important factor may have been Eliot Janeway's "proof" of the importance of the Controlled Materials Plan based on annual statistics of war production and his purple prose: the Controlled Materials Plan "flooded the fighting fronts with firepower." It appears to us, however, that the flood of weapons is better explained by analogy with an older process: perhaps historians should refer to the mobilization as the great gold rush of 1942.

Table 1: Allocations Under the Controlled Materials Plan, July-December 1943

Material	Estimated Supply	Budget Allotment Balance [Stated Requirements]	Allotment Issued to Prime Consumers	Percent Allotments Issued relative to Supply
Third Quarter, 1943				
Carbon Steel (million short tons)	14.750	16.383	15.261	103.5
Alloy Steel (million short tons)	2.503	2.758	2.566	102.5
Copper (million pounds)	355.000	383.081	337.407	95.0
Copper-Base Alloy (million pounds)	1,749.000	1,871.023	1,747.229	99.9
Aluminium (million pounds)	659.900	697.107	663.852	100.6
Fourth Quarter, 1943				
Carbon Steel (million short tons)	15.376	16.699 [19.599]	15.890	103.3
Alloy Steel (million short tons)	2.409	2.607 [2.944]	2.417	100.4
Copper (million pounds)	345.000	363.752 [450.393]	330.979	95.9
Copper-Base Alloy (million pounds)	1,819.000	1,895.821 [2,175.483]	1,823.440	100.2

Table 1: Allocations Under the Controlled Materials Plan, July-December 1943				
Aluminium (million pounds)	782.467	728.023 [803.445]	685.731	87.6

Sources and Notes. U.S. War Production Board, *Comptroller's Report: Operation of the Controlled Materials Plan,* (Third Quarter 1943, 77-78; and Fourth Quarter 1943, 78-79). For the Third quarter "estimated supply" appeared to be the initial estimate, for the fourth quarter it appears to be closer to actual shipments. Stated requirements are not available for the third quarter. Copper, copper-base alloy and aluminium were subdivided into more specific categories.

Table 2: Alternative Measures of War Output, Annual, 1940-1944

	1940	1941	1942	1943	1944
(1) War Production Board Total Munitions (billions, 1943 unit costs)	$2.8	8.5	31.6	56.4	61.3
(2) War Production Board Munitions, War Construction, and War Facilities Expansion (billions, 1943 unit costs)	$10.8	30.1	66.1	79.8	73.6
(3) Simon Kuznets Gross War Output Disregarding Efficiency (billions, 1943 resource costs)	$4.1	16.1	55.4	81.3	NA
(4) Simon Kuznets Gross War Output Preferred Efficiency Assumption (billions, 1943 final product prices)	$1.7	7.4	28.7	48.2	NA
(5) John W. Kendrick National Security Expenditures (billions, 1943 final product prices)	$3.0	14.4	51.7	80.4	92.0
(6) John W. Kendrick Gross Domestic Product (billions, 1943 final product prices)	$135.4	155.2	173.2	190.7	205.6
(7) Kendrick's National Security Expenditures as a percentage of GDP	2.2%	9.3	29.8	42.1	44.7

Sources by Row. (1) and (2): (Dewhurst 1947, 5). (3) and (4): (Kuznets 1945, 90). (5), (6), (7): (Kendrick 1961, 291-2, 300-1).

Table 3: Unit Root Tests				
Category	1940 m7—1943 m4		1942 m1-1944 m12	
	ERS	Zivot-Andrews	ERS	Zivot-Andrews
Aircraft	-0.216	-4.62 [Jan-42]	-2.06	-4.24 [Mar-44]
Ammunition	-1.79	-5.92*** [Jan-42]	-2.03	-4.99* [Dec-43]
Vehicles	-2.24	-4.52 [Jan-42]	-1.88	-3.56 [Jan-44]
Communication	-0.71	-2.72 [Sep-41]	-0.63	-3.55 [Oct-43]
Guns	-1.39	-3.40 [Jan-42]	-1.98	-3.33 [Mar-43]
Ships	-1.64	-3.92 [Jan-42]	-0.55	-3.75 [Oct-43]
Other	-1.27	-3.85 [Oct-41]	-1.46	-3.56 [Aug-42]
Total	-1.00	-4.14 [Jan-42]	-0.74	-3.83 [Oct-43]
*Sig at 10%, ** Sig at 5%, *** Sig at 1%				

Table 4: Quandt Likelihood Ratio Structural Break Tests				
Category	1940 m7—1943 m4		1942 m1-1944 m12	
	Test Statistic	Date	Test Statistic	Date
Aircraft	16.27***	Jan-42	35.43***	Apr-44
Ammunition	180.13***	Jan-42	51.11***	Dec-43
Combat	2.17	No break	5.95	No breal
Communication	11.03**	Jan-42	14.01***	Jan-44
Guns	16.06***	Jan-42	27.87***	Dec-43
Ships	9.89**	Jan-42	16.85***	Nov-43
Other	25.44***	Jan-42	8.36**	Sep-42
Total	16.59***	Jan-42	16.09***	Dec-43
*Sig at 10%, ** Sig at 5%, *** Sig at 1%				

Table 5: Quandt Likelihood Ratio Structural Break Tests (middle period)

	Jan 1942—Dec 1943	
Category	Test Statistic	Date
Aircraft	3.33	
Ammunition	7.41**	Feb-43
Combat	4.06	
Communication	1.69	
Guns	9.27*	Jan-43
Ships	3.47	
Other	12.86***	Sep-42
Total	4.22	
*Sig at 10%, ** Sig at 5%, *** Sig at 1%		

Table 6: Bai-Perron Breakpoint Tests		
Category	Number of Breaks	Break Dates
Aircraft	2	{Jan-1942, Apr-1944}
Ammunition	3	{Jan-1942, Feb-1943, Dec-1943}
Combat	0	
Communication	2	{Jan-1942, Jan-1944}
Guns	3	{Jan-1942, Jan-1943, Dec-1943}
Ships	2	{Jan-1942, Nov-1943}
Other	0	
Total	2	{Jan-1942, Dec-1943}

Table 7: Estimated Trends				
	Period I	Period II	Period III	Period IV
Aircraft	0.59	4.96***	-4.44***	-
Ammunition	0.93	2.45***	2.84***	2.49***
Combat	1.73	-	-	-
Communication	0.41	5.29***	-1.41***	
Guns	0.59	6.17***	2.00***	-2.54***
Ships	0.71	4.50***	-1.43***	
Other	0.53	6.50***	1.58***	
Total	0.65	4.35***	-0.77***	
***- Significantly different from trend in previous sub-period at the 1% level.				

Table 8: Labor Productivity in Munitions Production

Date	Employment in the Munitions Industry	Output per Worker	Monthly Rate of Change in Output per worker
	Millions	September 1943 =100	Percent
April 1940	4.0	NA	NA
September 1940	4.4	13	NA
September 1941	6.1	27	5.96
September 1942	8.4	79	9.01
September 1943	10.2	100	1.96
December 1943	10.3	109	2.97
June 1944	9.6	103	-.95
September 1944	9.3	111	2.33
December 1944	9.1	113	.72
July 1945	7.9	102	-1.44

Sources and Notes. Employment in the munitions industries: *Monthly Labor Review*, various issues. Production was created simply by dividing the index of total munitions production by the amount of labor. For the total munitions index: See text.

Table 9: CMP and the Rate of Growth of Output Pearl Harbor to Peak Production

Dependent Variable	Constant	Log of unemployed workers lagged once	CMP	R^2	DW
Total Munitions	-55.39 (3.06)	8.33 (3.45)	1.16 (.41)	.35	2.04
Aircraft	-14.95 (3.06)	2.99 (1.81)	-1.09 (.67)	.16	2.20
Ships	-47.45 (2.01)	7.24 (2.30)	.81 (.23)	.17	2.13
Guns	-84.75 (4.38)	12.35 (4.79)	1.23 (.41)	.54	2.16
Ammunition	-78.52 (3.05)	11.49 (3.35)	2.64 (.79)	.30	2.28
Vehicles	-38.02 (3.05)	5.66 (1.05)	.06 (.01)	.08	2.33
Communication Equipment	-83.33 (2.60)	12.51 (2.93)	3.41 (.73)	.13	1.91
Other Supplies	-64.41 (4.76)	9.72 (5.22)	1.45 (.84)	.44	1.80

Sources and Notes. Production: War Production board Indexes of the Physical Quantity of Munitions: see text. Unemployment (in thousands): (Dewhurst & Associates 1947, Appendix 1, column 5, 691-92). Absolute value of t statistics in parentheses; adjusted R^2s.

Table 10: Corporate Profits After Taxes at 1939 Prices, 1939-46

1939	$6,109	1943	9,264
1940	6,836	1944	8,673
1941	5,975	1945	7,611
1942	9,018	1946	10,566

Sources. Profits in millions and the GNP deflator: (U.S. Bureau of the Census 1975, 925, series V138; 224 series F5).

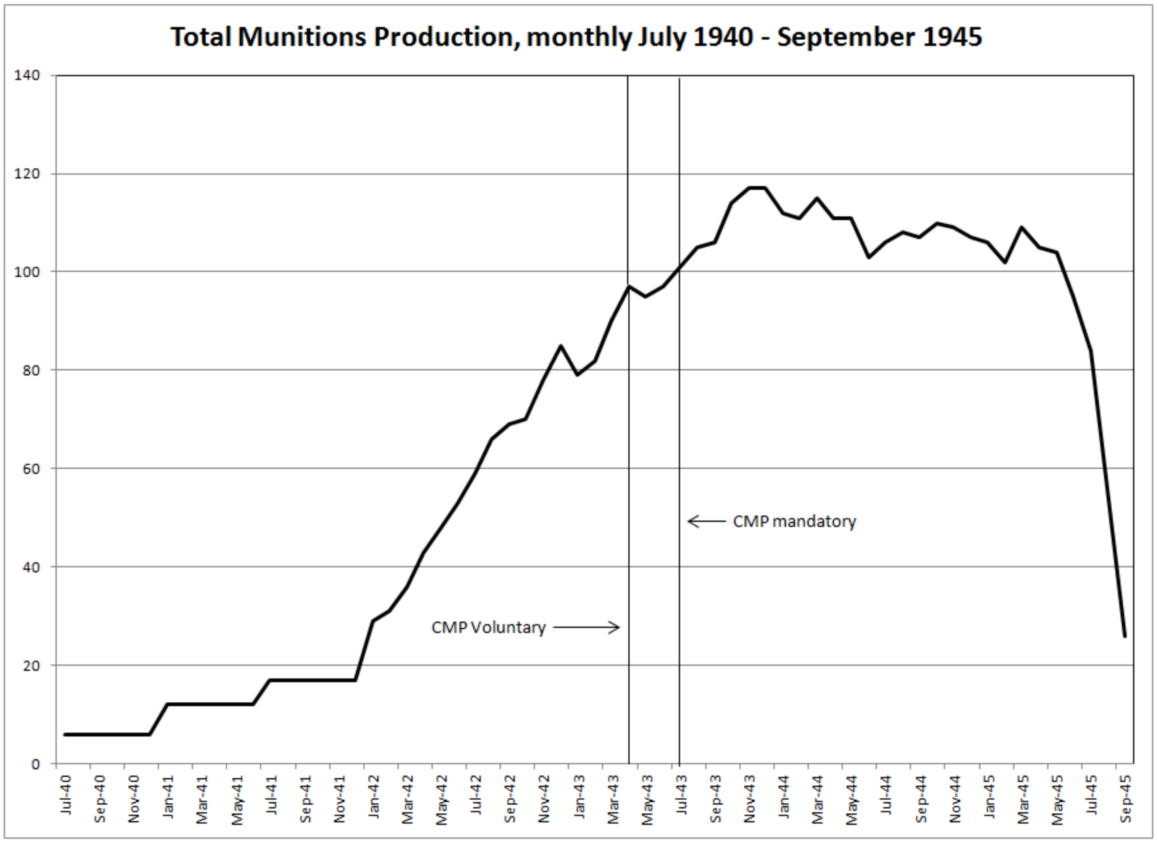

Total Munitions Production, monthly July 1940 - September 1945
140
120
100
80
60
40
20
0
CMP mandatory
CMP Voluntary
Jul-40
Sep-40
Nov-40
Jan-41
Mar-41
May-41
Jul-41
Sep-41
Nov-41
Jan-42
Mar-42
May-42
Jul-42
Sep-42
Nov-42
Jan-43
Mar-43
May-43
Jul-43
Sep-43
Nov-43
Jan-44
Mar-44
May-44
Jul-44
Sep-44
Nov-44
Jan-45
Mar-45
May-45
Jul-45
Sep-45

Figure 1

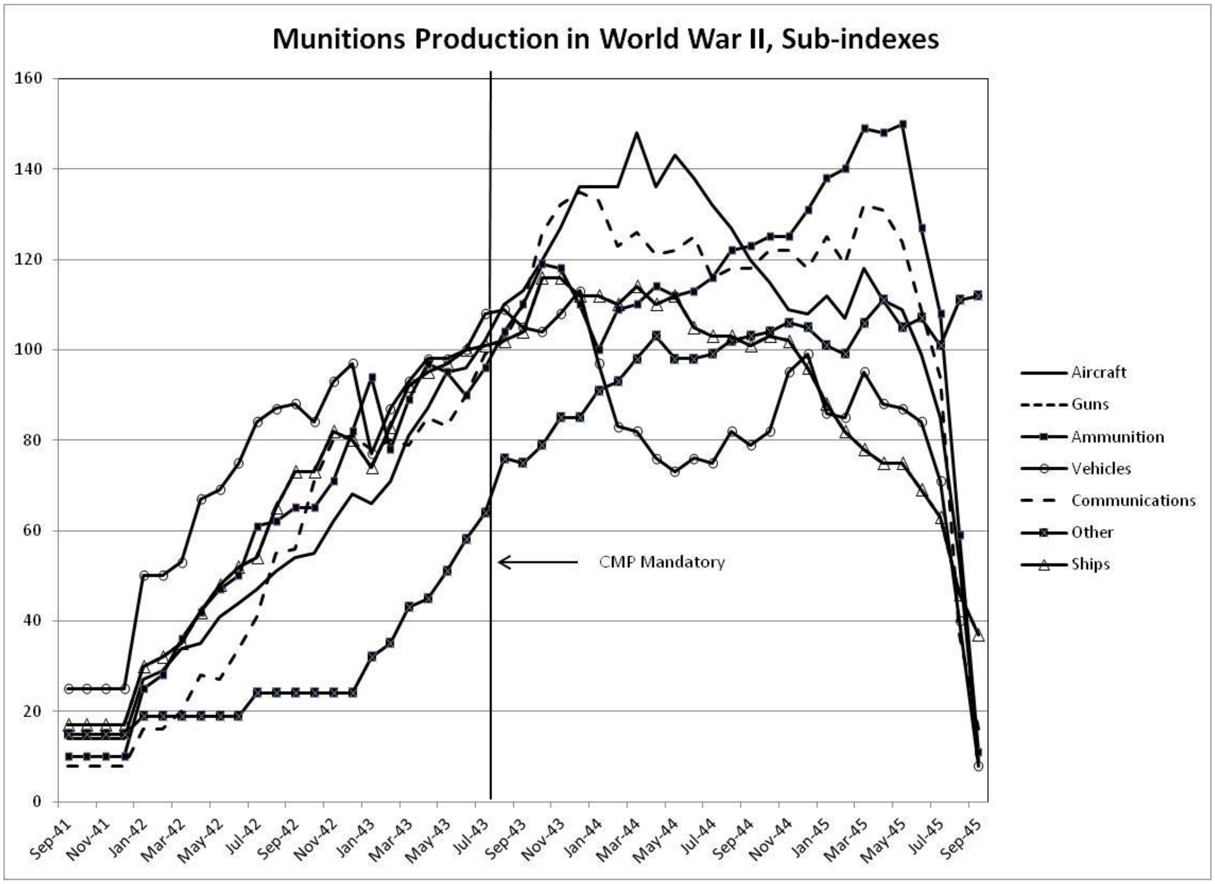

Munitions Production in World War II, Sub-indexes
160
140
120
100
80
60
40
20
0
Sep-41
Nov-41
Jan-42
Mar-42
May-42
Jul-42
Sep-42
Nov-42
Jan-43
Mar-43
May-43
Jul-43
Sep-43
Nov-43
Jan-44
Mar-44
May-44
Jul-44
Sep-44
Nov-44
Jan-45
Mar-45
May-45
Jul-45
Sep-45
CMP Mandatory
Aircraft
Guns
Ammunition
Vehicles
Communications
Other
Ships

Figure 2

Kuznets's Estimates of War Output and the CMP

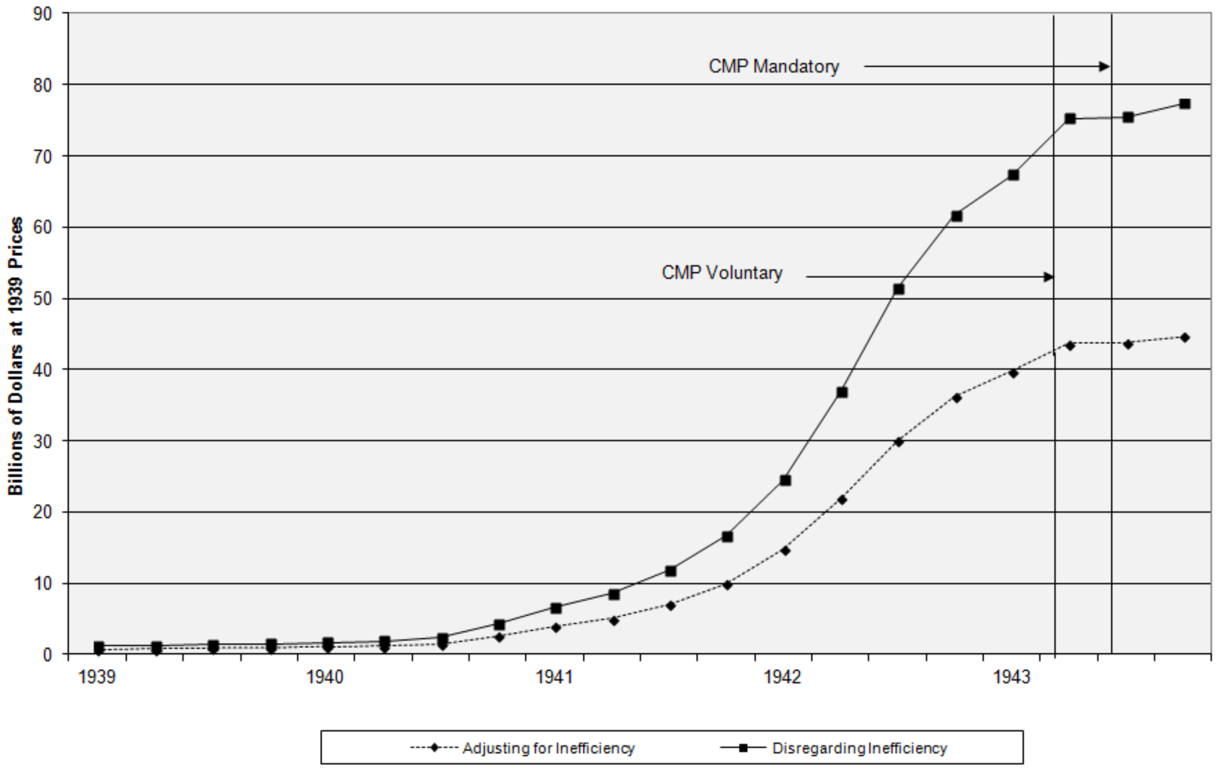


Figure 3

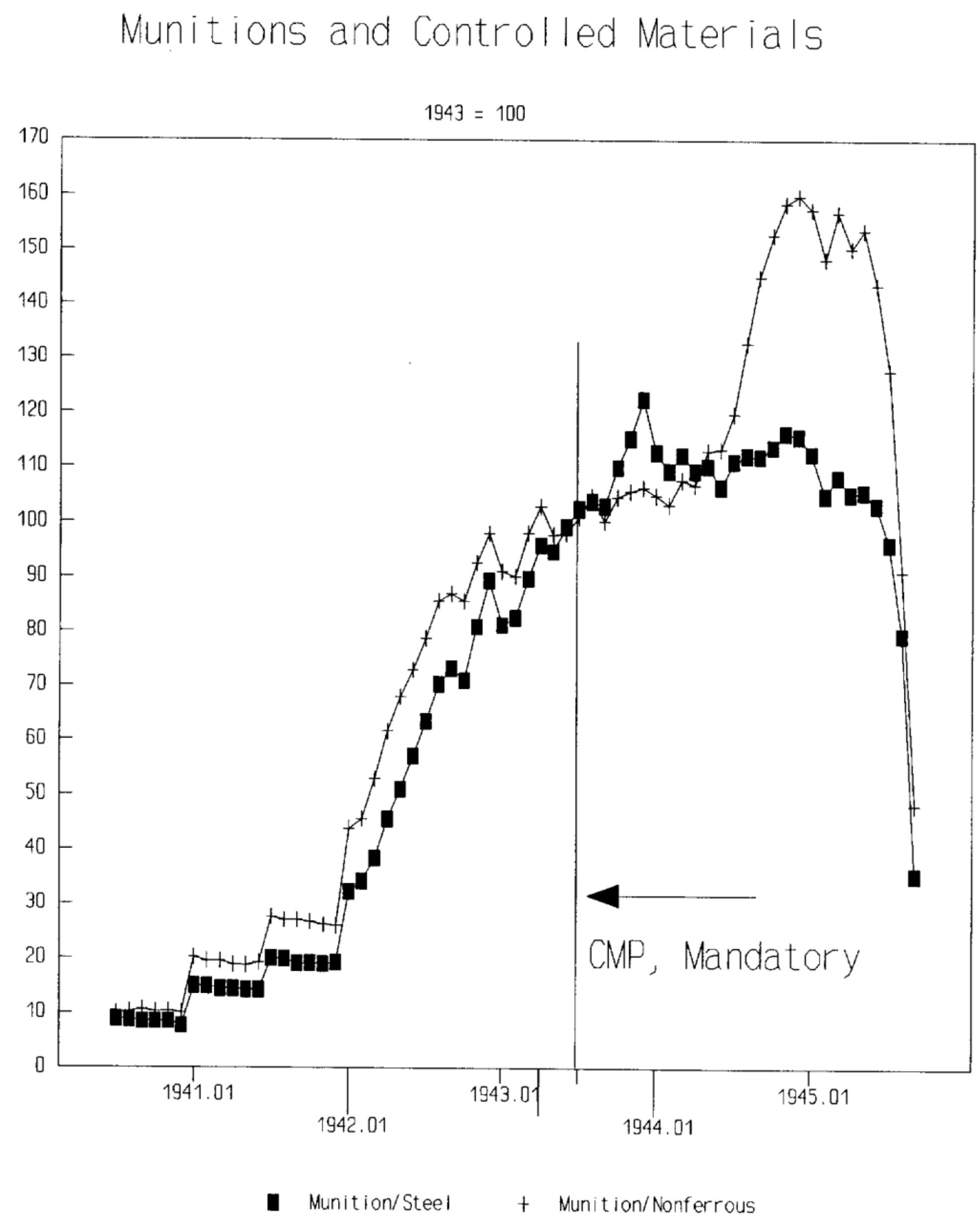

Munitions and Controlled Materials
1943 = 100
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
CMP, Mandatory
1941.01
1942.01
1943.01
1944.01
1945.01
Munition/Steel
Munition/Nonferrous

Figure 4

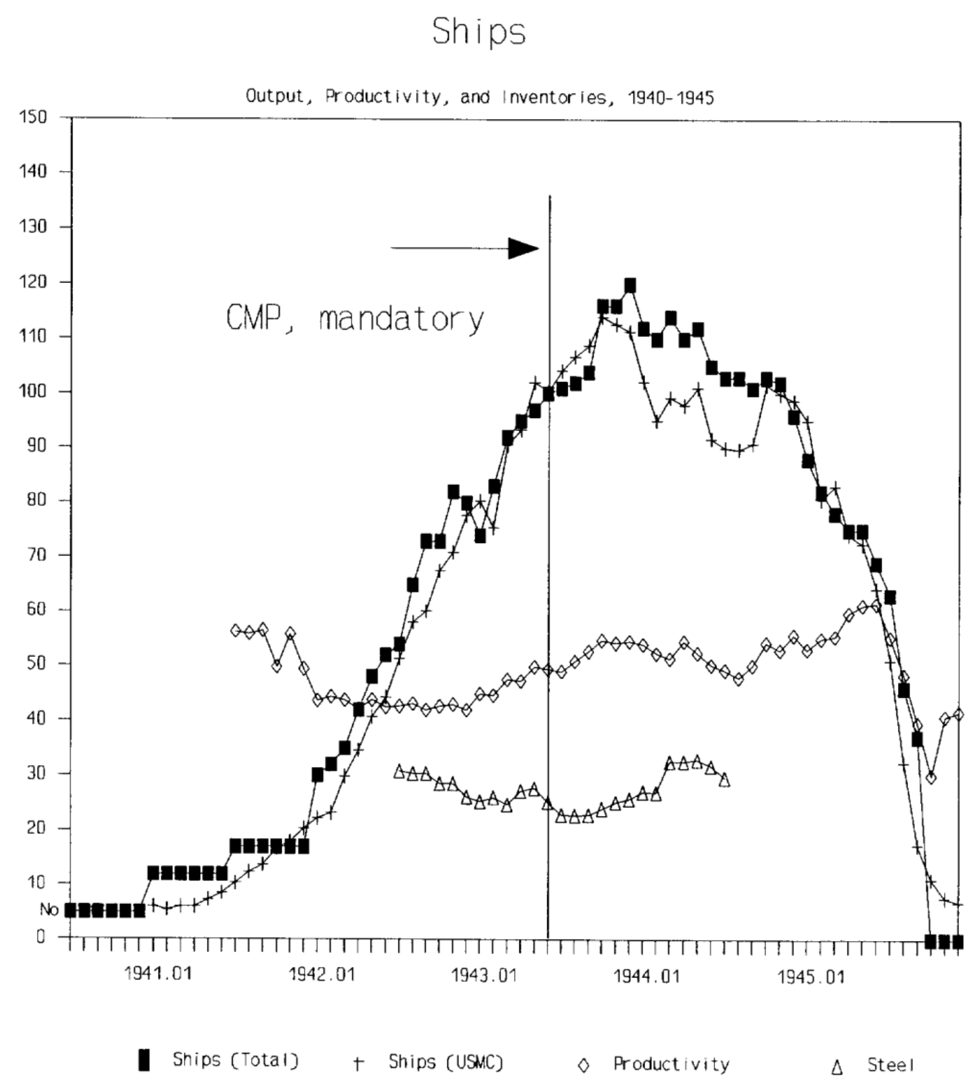
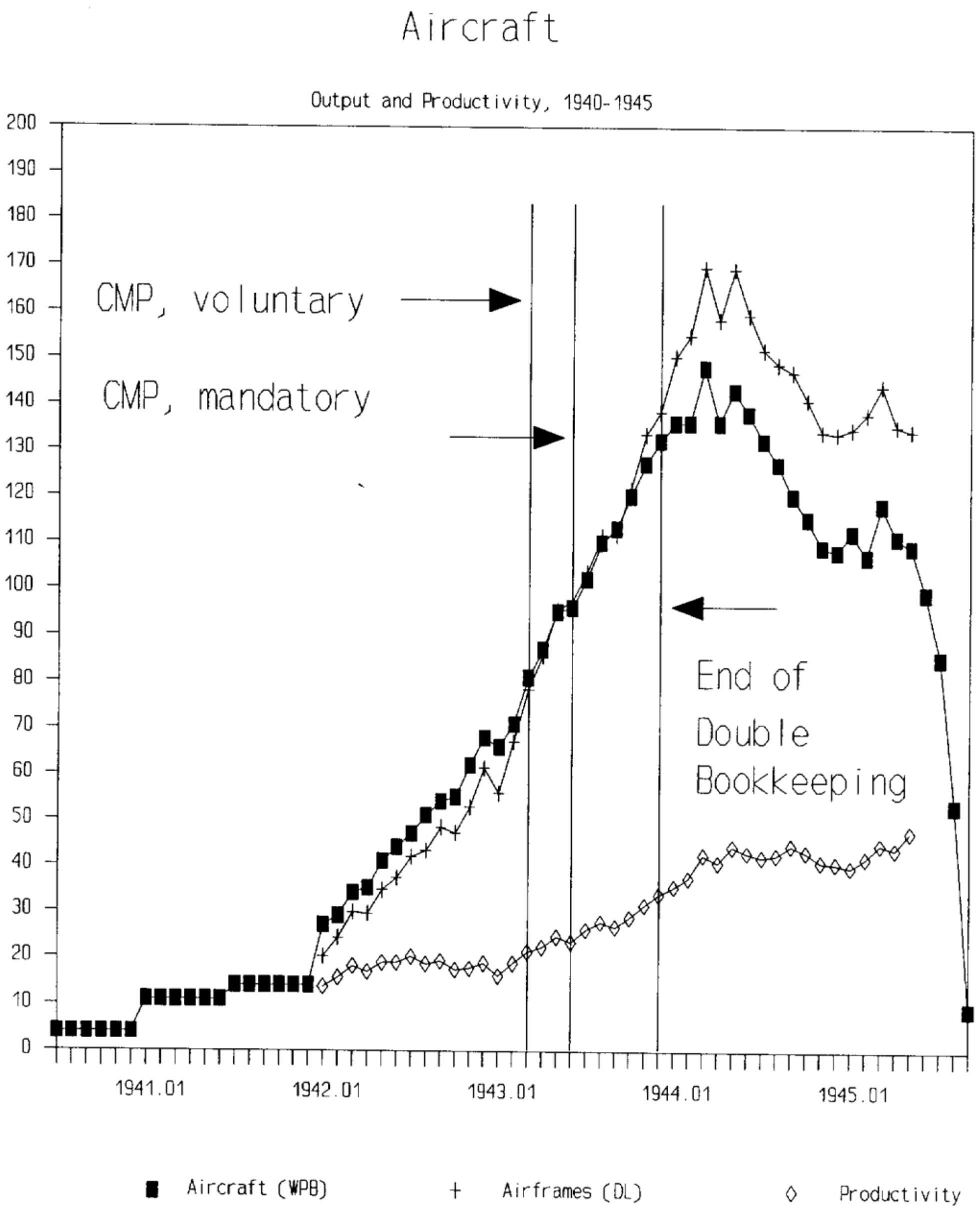

Ships
Output, Productivity, and Inventories, 1940-1945
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
No
0
CMP, mandatory
1941.01
1942.01
1943.01
1944.01
1945.01
Ships (Total)
Ships (USMC)
Productivity
Steel

Figure 5



Aircraft
Output and Productivity, 1940-1945
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
CMP, voluntary
CMP, mandatory
End of
Double
Bookkeeping
1941.01
1942.01
1943.01
1944.01
1945.01
Aircraft (WPB)
Airframes (DL)
Productivity

Figure 6

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