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Should Capital Input Data Receive a Utilization Adjustment?

by

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ABSTRACT

A common procedure in productivity research is to use estimates of the stocks of physical capital as proxies for service flows. A number of authors propose cyclical adjustments for capital input which, if large enough, will completely eliminate findings of procyclicality in the behavior of TFP. This paper argues that for the preponderance of assets in the fixed capital stock, fluctuations in utilization have little effect on user costs. In the aggregate, any adjustments to capital input data for utilization should consequently be small, much smaller, for example, than those suggested by Solow (1957), Griliches and Jorgenson (1966), Tatom (1980), or Shapiro (1993).

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Introduction

A common procedure in productivity research is to use estimates of the stocks of physical capital as proxies for service flows. This practice is of little concern if one is exploring growth across different time periods, because in such inquiries one typically measures from peak to peak, in part to abstract from cyclical influences on productivity. Once one gets into research on those cyclicality influences themselves, however, it can matter a great deal.

A variety of studies suggest that both TFP and, to a lesser degree, labor productivity, are now and have for over a century been strongly procyclical in the United States. Using data for the private nonfarm economy, Field (2008b), for example, finds that between 1890 and 2004, a one percentage point decline in the unemployment rate added about .9 percentage points to the growth rate of TFP. This elasticity is stable across periods during which the trend growth rate of TFP was quite different, and its magnitude has been unaffected by whether the economy was close to potential output or far away from it.

While the finding of procyclicality builds on the results of prior studies, the analysis of the underlying microeconomics departs from the conventional. The emphasis is not on the voluntary labor hoarding often adduced to account for procyclicality in output per hour (Fay and Medoff, 1985).[1] Whatever tendency there is for firms, having retained

[1] Labor productivity in the private nonfarm economy is, like TFP, procyclical, although the magnitude of the effect is substantially weaker, and for the postwar period one can't reject acyclicality (see Field, 2008b). The continued rise in output per hour during the 2001 recession and during the recession that began in December 2007 is reflective of this.

workers during the downturn, to refrain from hiring during an upturn, it is a tendency that weakens and disappears in the last year and a half or two years of an expansion, when companies add both employees and hours at a rapid rate. Gordon (1979, 1993) calls this the end of expansion effect. This means, as an empirical matter, that labor hoarding can't be the full explanation for procylicality.

The emphasis is rather on the involuntary hoarding of capital inevitable in a private enterprise system. Capital owners are in the same position with respect to the physical capital stock as were southern plantation owners prior to the Civil War with respect to their slaves. Whether the physical capital is owned, leased, or rented is largely irrelevant. Someone has to hold (own) it and bear the incidents of ownership. These incidents include costs as well as benefits. While benefits drop along with output and revenue flows during recession, costs, and, I will argue, service flows, by and large, do not.

For some types of fixed assets, depreciation and overall user costs decline significantly with reductions in utilization, but for many other assets – indeed, the preponderance -- there is little effect. The consequence is that, in the aggregate, the user cost of capital is affected only slightly by changes in the output gap. Since capital costs are largely invariant to utilization, and since output rises as the output gap closes, capital productivity is strongly procyclical, and as one emerges from a recession, unit costs face downward pressure because these costs, largely fixed over the short run, are spread over a larger flow volume of output.[2]

To give a concrete example, the total factor productivity of a hotel rises with its occupancy rate, just as the TFP of an airliner rises with its load factor. In each case user costs are largely invariant to utilization. The airline company must pay for the service

[2] As the output gap closes, these dynamics are eventually counteracted by rising labor costs.

flow of the aircraft – the pure holding cost of owning physical capital[3] along with depreciation – whether the aircraft is full or half empty, and the same is true for the hotel owner. With a capital stock essentially fixed in the short term, firms, and the economy in the aggregate, experience short run economies of scale as an output gap closes.[4] It is true that the user costs of machinery, particularly mechanical machinery, respond differently to fluctuations in utilization. But the preponderance of assets are closer in their cost and productivity behavior to those of the hotel. Rising TFP as one approaches potential output from below is a phenomenon that is both real and economically meaningful.

Utilization does influence user costs and thus estimates of service flow. But these effects are nowhere near as large as those suggested by Solow (1957), Griliches and Jorgenson (1966), Tatom (1980), or Shapiro (1993). Holding costs are almost entirely invariant to utilization, and the response of depreciation to fluctuations in utilization is different for different assets, with depreciation for important asset classes essentially unaffected by how intensely the assets are used. For historical/ time series investigations of cyclical effects on productivity, as well as cross country comparisons where the countries are at different stages of the cycle, it can make a great deal of difference whether or not we make a utilization adjustment for capital input, and if so, how large it is.

Different Conceptualizations of the Cycle and its Causes

In this work a business cycle is understood to be both defined and measured by fluctuations in an output gap for which changes in the unemployment rate are an

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[3] The fact that the airline may lease the plane is irrelevant, since the observation then applies to the leasing company. Ultimately, down the line, someone owns it. I abstract here from any capital gains or losses on the aircraft.

[4] For analysis of the microeconomics, see Berndt and Fuss (1986, pp. 19-21).

imperfect proxy. The emphasis is on involuntarily idle resources – both labor and capital -- rather than on output fluctuations per se. Most business cycles are assumed to be produced by fluctuations in aggregate demand.

Real business cycle theorists also believe that procyclical TFP is real and economically meaningful, but their definition of the cycle and the understanding of its causes are quite different. RBC proponents believe that deviations of TFP from trend are the consequence of technology shocks and that these shocks are the ultimate drivers of fluctuations in the growth rate of real output. TFP is definitionally procyclical because technology shocks cause cycle phenomena understood to mean fluctuations over the short run in the growth rate of real output (Prescott, 1986).

The RBC interpretation, however, confronts a serious problem. TFP doesn't just grow at different rates, which might plausibly be attributed to variations in the arrival of new technologies. It also periodically and systematically declines – its level actually falls -- particularly during recessions. RBC advocates must provide plausible narratives to account for these declines in levels. Aside possibly for 1974 (oil price shocks) this challenge has not been met, and this is particularly the case for the worst years of the Depression.

From 1890 through 1948, average annual growth of TFP in the U.S. private nonfarm economy was 1.7 percent per year, but the standard deviation was 5.4 percentage points. The level of TFP declined in 23 of those 58 years, with especially large declines in 1930, 1931, 1932, and 1933.[5] For the postwar period (1948-2004), average TFP growth was 1.4 percent, with a standard deviation of 1.8 percent, reflecting

[5] From a growth accounting perspective, at least 12 percentage points of the more than 30 percent decline in output over these 4 years was due to declining TFP.

the reduced volatility of the business cycle, particularly in the last quarter of the century. Still, the level of TFP declined in 1956, 1969, 1970, 1974, 1980, 1982, 1991, and 1995. If we are to take seriously the claim that TFP deviations from trend are principally the reflection of technology shocks, these declines – and those during the prewar period -- must be explained.

Although it is necessary to situate this work in relation to current trends in macroeconomic research, the intent of the paper is not to provide a critique of RBC approaches to macro history.[6] It is rather concerned with a potentially more damaging challenge to the finding and interpretation of procyclical TFP advanced here: namely the suggestion that there is in fact nothing to explain. The argument advanced by Shapiro and others is that TFP procyclicality is simply a statistical artifact resulting from the failure adequately to make a utilization adjustment for capital input.[7] The argument of this paper is that whatever its interpretation, the phenomenon of procyclical TFP is indeed real. If capital input requires a utilization adjustment it should be small, and will not wipe out the empirical finding of procyclicality.

The Argument for Adjustment

Findings regarding the procyclicality of TFP, such as Field, 2008b, are based on capital input data which use the stock to proxy for the service flow. The objection of capital input adjustors is that even if the capital stock doesn't change much over the cycle, service flow does. Thus capital service flow is cyclical, possibly even more

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[6] Those interested should consult Temin (2008).

[7] If this were true it could, of course, also present concerns for RBC proponents who use TFP data based on capital inputs which have not been adjusted for utilization. Again, my own view is that the RBC approach produces models which are grossly inadequate for understanding macroeconomic history – or the current financial/economic crisis. But for those working within the tradition, this issue of utilization adjustments for capital input should matter, because it potentially influences the macro data series underlying the model construction/calibration exercises.

cyclical than labor input (Tatom, 1980). Capital service flows in a trough, a proponent of large utilization adjustments will argue, are much lower than they are during the peak, even if the measured stock doesn't change much.

To the degree that we make cyclical adjustments to capital input, such adjustments will weaken and, if large enough, completely eliminate the finding of procyclicality (Tatom, 1980; Shapiro, 1993; Burnside, Eichenbaum, and Rebello, 1995)). The arithmetic is simple: lowering capital input in the trough raises the calculated level of TFP in the trough, thus reducing or even eliminating the trough to peak increase in TFP at the heart of the procyclicality dynamic. Because of its implications for procyclicality, it is important to know whether a cyclical adjustment to capital input is justified, and, if so, how large it should be.

Most calculations of total factor productivity, including those provided by the Bureau of Labor Statistics, do in fact proxy capital input using estimates of the capital stock. In so doing, researchers proxy the service flow from the stock in the same way we would proxy the service flow from a slave or owned cattle from an estimate of the value of the stock. Obviously this is not exactly right, because it is possible to work a slave or an ox or some types of physical capital in a more or less intense fashion, and this could affect depreciation as well as overall user costs.

It is also true, however, that we commonly associate with an asset, whether it be a horse, a machine tool, a warehouse (or, in the case of the antebellum South, a slave), a standard service life. In doing so, we are implicitly assuming "normal" or "optimal" levels of utilization and idleness (Winston, 1974). To talk in terms of service lives is to imply that the annual user costs of assets are largely independent of the intensity of their utilization.

We see here two different and in some ways conflicting views of the nature of a fixed asset. The first imagines a capital good as a non-rechargeable battery, with a certain number of hours of use after which it is drained and must be disposed of. The second, the service life view, sees the asset as having a "normal" lifetime, a period of time largely independent of how intensely the asset is exploited. In the first instance higher utilization means the fixed asset gets "drained" more quickly, while in the second, annual user costs, which include depreciation, are largely unaffected by how intensively it is used.

Differential Response of Depreciation to Utilization

A nation's fixed capital stock consists of different kinds of assets, and it stands to reason that the depreciation behavior of these different types might be closer to that suggested by one or the other of these archetypes, or by some combination of the two. This paper is about which classes of assets fall into which categories and what this means for a possible cyclical adjustment to capital input. A key element of the argument is that the second type captures the essential features of a far wider range of fixed assets than is typically recognized. Utilization exercises a significant effect on the user costs only of a small fraction of the stock. Consequently, the impact of utilization on depreciation, overall user costs, estimated service flows and, ultimately, cyclically adjusted measures of TFP, is very small.

When Robert Solow wrote his seminal article in 1957 on "Technical Change and the Aggregate Production Function," he considered it natural to try and treat labor and capital symmetrically. He reasoned that if part of the labor force were unemployed during a particular period, we would reduce our estimate of labor input accordingly. He suggested we should do the same for capital, and in fact used the share of the labor force employed as the basis for that adjustment, multiplying it by his estimates of the capital stock to get a series that he believed more accurately proxied for service flow over the cycle than would the unadjusted capital stock series.

Others have suggested different bases for a utilization adjustment. Zvi Griliches and Dale Jorgenson (1966, p. 60) employed data on hours of operation of machines in the electric power industry to adjust capital input for the entire private domestic economy.[8] John Tatom (1980, pp. 390-1) used a somewhat broader foundation, the Federal Reserve Capacity Utilization Index, to adjust input for the private nonfarm capital stock. Based on these adjustments he claimed that capital input actually declined more than labor input during a recession, and attributed the finding of procyclical labor productivity to capital deepening as one comes out of a recession, capital deepening resulting not from procyclical additions to the capital stock but from increases in utilization and thus service flow.

This is in sharp contrast to the argument in Field (2008b), in which procyclical TFP is associated with capital shallowing (declines in the capital – labor ratio) but sharply rising capital productivity (output per unit of capital) as one comes out of a recession. Tatom's procedure takes capacity utilization data from a small and shrinking portion of the economy (the manufacturing sector) and applies them to the entire private nonfarm economy. But my critique of these adjustments runs deeper than the narrow base for the

[8] Denison criticizes these capital utilization adjustments as "wholly unwarranted" (1969, p. 26), but from within a conceptual framework which, like Griliches and Jorgenson, treats machinery (equipment) as a representative capital good.

data used in the adjustment. Even if we could persuade ourselves that capacity utilization measures in manufacturing were a good proxy for the entire economy, it would be a mistake to reduce our estimate of capital input by the full percentage by which the use of an input falls short of what would be true at potential. Fluctuations in utilization affect depreciation flows differently for different types of assets, and holding cost as well as depreciation contributes to user cost. Holding cost is largely invariant to utilization, and for much of the capital stock, so too is depreciation. In the aggregate, the user costs of the capital stock – and the service flows from it - change little with changes in utilization.

Mathew Shapiro (1993) used actual data on operating hours of equipment within manufacturing to make an adjustment for the service flow from the manufacturing capital stock. Craig Burnside, Martin Eichenbaum, and Sergio Rebello (1995) performed a somewhat similar exercise, in their case using data on electricity consumption as the basis for the adjustment. For the same reasons, the cyclical adjustments to capital input proposed by both of these studies are too large.[9] They do not take into account the degree to which parts of the capital stock – buildings especially -- have user costs that react little to how often the machines within them are operating. Even the machines themselves have associated with them a pure holding cost of capital as part of their annual cost, and this charge is largely invariant to utilization.

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[9] In response to the 1979 report of the Panel to Review Productivity Statistics, which was chaired by Albert Rees and set up by the National Research Council, the Bureau of Labor Statistics has published TFP estimates beginning with the year 1987, from which growth rates can be calculated. According to Jorgenson, Ho, and Stiroh (2008) these calculations "employ capital services rather than capital stock as a measure of capital input, which represented a significant step forward in productivity analysis" (p. 8). Note however, that the BLS is not adjusting the capital input series for the types of changes in utilization associated with business cycles. Rather, they are attempting to refine the service life view (rather than the non-rechargeable battery view) of a fixed asset. According to chapter 10 of the BLS Handbook of methods, "The efficiency of each asset is assumed to deteriorate only gradually during the early years of an asset's service life and then more quickly later in its life. These "age/efficiency" schedules are based, to the extent possible, on empirical evidence of capital deterioration." http://www.bls.gov/opub/hom/ , accessed on January 5, 2009.

Solow, who was interested primarily in growth, was not especially concerned with the cyclicality question. Shapiro and Tatom were, and both argued that cyclically adjusting capital input weakened or even eliminated the procyclicality of productivity measures. Again, the arithmetic is simple: lowering estimated capital in the trough raises the level of TFP in the trough, and thus narrows and ultimately eliminates the trough to peak rise which drives the procyclicality finding.

In understanding why the proposed cyclicality adjustments are too large, one must confront some deeply ingrained ways of thinking about fixed assets. These include a tendency to focus disproportionately on the manufacturing sector, as well as a tendency to think of the representative capital good as a machine (Field, 1985). Even today, with the equipment share in the fixed asset stock having risen in recent years, structures account for over four-fifths of the net private fixed asset stock (current cost) in the United States (see Table 1 below). The Bureau of Economic Analysis data go back to 1925, and the share of structures has never fallen below 80 percent since that date. In the United States, a machine is not now and never has been a representative capital good.

So we are better off if we begin by thinking of the representative capital good as a structure: a warehouse, commercial office building, or hotel. Structures are different from machines. They have few moving parts, they rely much more on structural as opposed to mechanical or electrical engineering, and they have much longer service lives. Building on le Corbusier's views, we can usefully think of buildings as machines for producing structural services. But, even more so than is true for conventional machines, these structural services have a use it or lose it aspect to them.

The basic function of a structure is to enclose space and protect it from the elements. Whether or not the building is "turned on" or "turned off", occupied or not, empty or half full, it continues to enclose space. The structure simply emits these enclosing services. Whether they are used constructively in producing marketable goods and services or whether they simply vanish into the air is beside the point in terms of the real costs to the economy or the holder of the asset. Whereas the economic benefits to the holder of the asset decline with utilization, the costs by and large do not. Once the structure is complete, the services flow, and if a firm borrowed money to acquire or construct it, or used its own funds, it has to pay for these service flows, either in interest payments, or in the opportunity cost of not having invested its funds elsewhere. And real depreciation costs continue whether the warehouse or hotel is empty or full. For these types of assets the value of the stock is a perfectly good starting point for estimating the value of the service flow.

Many of these considerations also apply to a machine. But there are important ways in which a structure differs qualitatively from a producer durable. First, the depreciation on a structure, for example how rapidly the exterior paint oxidizes or the roof wears out, is almost entirely unaffected by how full or empty it is. Secondly, the service life of a structure is likely to be far longer, so that the depreciation flow, which we have in any case already established is largely unaffected by the building's utilization, will be dominated by the pure holding cost of the structure in determining its annual user cost.

Because machines have shorter service lives, and because some types of machines have the potential to wear out more quickly if they are utilized (turned on, not idle) more frequently or more intensely during a year, their overall user cost is likely to be measurably influenced by fluctuations in utilization. It is this reality, combined with our tendency to think of the representative capital good as a machine, that leads to what seems the obvious conclusion that utilization will have a big impact on aggregate service flow, and that consequently we ought to make sizable adjustments to capital input to account for variations in utilization associated with a rising or falling output gap. My intention in this paper is to demonstrate why this intuition is faulty.

Note to begin with that the very vocabulary we use to describe machine use is not really applicable to structures. A machine is on or off; if it's not in use it's idle. This language is not nearly as applicable to a structure. What we generally want to know about a hotel or a warehouse is not whether it's on or off, but how full or empty it is.

Additional Fixed Asset Categories

So far we have considered two broad asset categories: structures, long lived, with depreciation flows largely unaffected by utilization, and archetypal machines, shorter lived, in which utilization affects the rate of depreciation. We now consider a third type. Hybrids are capital goods that share attributes of both machines and structures and another important feature: they move. An airplane, truck, railroad car, or a steamship falls officially under the subcategory of transportation equipment, but can be thought of as a moving structure. Unlike a warehouse, the on/off/idle vocabulary is relevant in thinking about its depreciation costs. Hours of operation, and in particular the number of takeoffs and landings, for example, matter in terms of the life of an airframe. But unlike a drill press, many assets within the transport equipment category are also like structures in the sense that how full or empty they are influences their value added but not their costs. As a consequence, their total factor productivity, like that of structures, is strongly procylical. We can expect utilization to have some effect on depreciation flows, because of the hours of operation effect, but much less so than in the case of stationary non-enclosing machines.

Finally, we can identity a fourth type of asset, another group of assets in which utilization has little influence on user costs. These are the capital goods within the information processing and software subcategory of producer durables. Like a stationary machine such as a drill press, they are, relative to structures, short lived, but they rely more on electrical as opposed to mechanical engineering. Their relative lack of moving parts means that friction is a lesser issue at higher utilization rates. Obsolescence, on the other hand, particularly in recent years, plays a larger role in influencing depreciation than for the other three categories. The rate of technological obsolescence is almost entirely unaffected by a cyclical slowdown.

Modern electronic data processing equipment, telecommunications equipment such as cellular telephones or switches and fiber optic cable, are assets for which technological obsolescence affects depreciation but for which bitstream variation is unlikely to have any noticeable effect.   Software, now also considered a fixed asset, is, for different reasons, also an asset category for which utilization will have little or no effect on depreciation. The code underlying Microsoft Word is simply unlikely to reach the end of its useful life faster if I write more papers with it. Frankly, the same is true for the IBM Thinkpad X31 on which this is being composed. The value added of these assets, like structures and hybrids, rises sharply as one approaches potential output from below, while their costs do not.

To summarize, we can think of fixed assets as falling into one of four broad categories. The largest and most important by value are those whose primary function is to enclose space and provide protection from the elements. We call them structures, they are long lived, and their user cost is almost entirely invariant to how full or empty they are. Note that the "soft" parts of a hotel or commercial office structure – furniture and fixtures – which we might expect to be sensitive to utilization, are considered producer durables, not part of the structure itself.

The second broad category consists of archetypal machines. They are producer durables, often heavily dependent on mechanical engineering, with many moving parts, with the consequence that friction takes a toll on useful life and is heavily influenced by hours of operation or on/off cycles. Electrical engineering is frequently involved in these assets in the sense that the devices can be powered by electric motors, but the primary function of the motors is to produce mechanical motion of either a rotary or reciprocating variety. These assets are off or on, and utilization does influence wear and tear, which may be a complex function of how long they are on, at what speeds they are operated, and how frequently they are turned on or off.

A third category consists of what we can think of as hybrids. They are classed as producer durables, because, unlike structures, they depend heavily on mechanical engineering and can be moved, in many cases under their own power. Like structures, however, they generally also enclose space, and their value added is affected by how empty or full they are. Because these assets can be turned on or off, have moving parts, and depend on mechanical engineering, their depreciation is somewhat sensitive to hours of operation. But a more significant influence on their productivity and our measure of their utilization is how fully loaded they are.   On average they are longer lived than archetypal machines, but closer to them in life expectancy than structures. Assets in this category include busses, trucks, railway cars, steamships, and aircraft.

Finally, we have a category of producer durables which relies almost exclusively on electrical engineering and has few moving parts. These are not structures, but for different reasons, their depreciation is also almost entirely independent of utilization. Examples would be fiber optic cable, electronic data processing and telecommunication equipment, and software.

These asset categories clearly differ not only in how important they are by value, but also in how much their depreciation depends on utilization. In discussing depreciation, Internal Revenue Service Bulletin 646 states that “To be depreciable, your property must have a determinable useful life. This means that it must be something that wears out, decays, gets used up, becomes obsolete, or loses its value from natural causes” (2006, p. 6). Three of the five potential contributors to depreciation: “loss of value from natural causes”, “decay”, and “obsolescence” are almost entirely a function of the duration of time the asset has been in service, and are not influenced by whether or not its service flows have been contributing to the production of marketable goods and services. Only two, “wearing out” or “getting used up,” can, particularly in the case of an archetypal machine, be attributed to more intensive use, although they also might be purely a function of time in service (as in the wearing out of a roof). The relative importance of these different contributors to depreciation varies across the four broad asset categories identified.

Sensitivity of Depreciation and Overall User Costs to Utilization

The objective is now to sort fixed assets into these different classes and provide more specificity about how long lived they are (which affects their annual holding costs) and how sensitive their depreciation may be to changes in "utilization." The goal is to estimate how sensitive aggregate user costs are to fluctuations in the output gap, how large a cyclical adjustment to capital input this might entail, what would be the impact of this adjustment on a TFP series, and whether such an adjustment threatens the procyclicality conclusion.

We have well worked out frameworks for measuring the user cost of both labor and capital, but they are not symmetrical, and in a non-slave society, these costs do not vary symmetrically over the business cycle. The user cost of labor is simply the wage (or salary), including paid benefits. If it's paid for, we consider these costs as proxies for service flows inputted into the production function. If we organize this paid labor poorly, we won't get much output, but that's partly what we're trying to pick up in our measures of productivity. If the economy turns down, and demand for labor service drops, the private business sector simply fires or does not hire labor, thus effectively removing a portion of the labor force from its books.

Following Jorgenson (see, for example, Griliches and Jorgenson, 1966, p. 52), we can understand the user cost of capital as consisting of three parts: the net stock of capital K times the interest rate r, which represents the pure opportunity cost of holding a physical asset, the depreciation rate δ times the stock of capital K (depreciation costs), plus any capital gains or losses on the asset.[10] Note that none of these terms is applicable

[10] The following discussion focuses on the first two of these terms and ignores the third.

when reckoning the user cost of labor in a non-slave society, and that the consolidated private business sector cannot simply fire capital in a downturn.

Consider a house. A house is a machine for producing housing services. Those services are either used (consumed) or they perish forever. The "machine" just sits there, emitting the shelter services. Obviously, if those services are used and paid for in a rental market, or consumed by an owner occupier, measured capital productivity goes up. But whether or not that takes place, the fixed asset sits there, it keeps emitting its service flow, and whoever owns it is on the hook for the ongoing depreciation and the pure opportunity cost of holding physical capital.

The same argument applies to a warehouse. The warehouse can be thought of as a machine for keeping goods safe, dry, and secure. It sits there emitting these enclosing services, and the user cost of the warehouse is unaffected by whether it is full, half full, or empty, or how rapidly the goods inside turn over. And the same can be said for a hotel, manufacturing structure, or commercial office space: the services are either used in producing marketable output or forever lost.

The situation is different with respect to labor. In a non-slave society humans are more than machines for producing physical or intellectual labor. Individuals may voluntarily remove themselves from employment or the labor force. As far as the private business sector is concerned they are then off the books. No business unit is responsible for paying for these "unused" service flows. And if the business sector fires workers or fails to hire them as an output gap rises, workers are also off the books, and any obligations to pay for an unused service flow disappear. In a non-slave economy, the business sector does not have to pay the pure opportunity cost of holding human capital when it sits idle. Firms may voluntarily choose to retain labor during a downturn because of the costs of hiring and training workers, but this is a choice, in contrast to the situation faced with respect to their fixed assets.[11]

(TABLE 1 ABOUT HERE)

For long lived structures with few moving parts, relying little on mechanical engineering, where friction from contact with humans or equipment is relatively low, an adjustment to capital service flow for utilization should be negligible. "Utilization" fluctuations have almost no influence on user costs because they have almost no influence on true depreciation, and because depreciation is a relatively small part of user cost, dwarfed by the pure cost of holding the asset.

This matters a great deal in the analysis below, because, as Table 1 shows, throughout the twentieth century more than four fifths of the United States net fixed asset stock (current cost) has consisted of structures. This has remained true in spite of the rise in the share of equipment (mostly information processing equipment and software) at the expense of the share of (nonresidential) structures. The increase in the equipment share would have tended by itself to make TFP more sensitive to a cyclical adjustment. But within the producer durables category, the share of transportation equipment has declined (due in part to the lesser importance of railway capital) while information processing equipment and software has risen. The latter category relies almost entirely on electrical rather than mechanical engineering and obsolescence plays a much greater role in depreciation; utilization influences are negligible. These trends have mitigated the

[11] Obviously, if a firm rents its capital goods it may, during a recession, cease renting them, but this simply transfers the problem to the rental firm, which is left holding the assets.

impact of the overall increase in equipment as a share of the capital stock on the sensitivity of its service flow to utilization.

The impact of utilization on depreciation and thus on user cost is clearly different for an archetypal machine. This is so for two reasons. First, such machines depend heavily on mechanical engineering. They have moving parts, often many. Friction produces wear and tear, and economic depreciation rises if the machine is operated more of the time or more intensively, or is stopped and started more frequently. Second, because the asset has a shorter service life, depreciation charges figure more prominently in the overall user cost of the asset.

How much difference might heavy use make in terms of the true depreciation of an asset, particularly an archetypal machine? Obviously this will differ depending on the particular capital good in question. But we can get some idea of the empirical magnitude of the effect by studying the behavior of an asset for which there is a thick market in used capital goods with differing degrees of utilization. These assets are automobiles, and their prices are available online at http://www.kbb.com.[12]

To address this question I examined data from June 2007 comparing prices on 2006, 2005, 2004, and 2003 models of a popular family vehicle, a Toyota Camry LE 4 DR sedan. This vehicle is widely held and widely traded, heavily dependent on mechanical engineering, and consequently one in which friction matters in influencing wear and tear. It is also an asset which did not undergo major model or functionality changes across this time period; thus technological obsolescence is a relatively small

[12] It is true that an automobile is transport equipment and thus shares some of its characteristics with busses or aircraft. But the carrying capacity of a car is relatively small (it is a personal vehicle), and thus load, as opposed to hours or miles of operation, has a relatively smaller influence on our measure of its utilization. The widespread availability of price data in secondary markets is my justification for using this asset class as the basis for estimates of the sensitivity of depreciation of an archetypal machine to utilization.

issue. The analysis is based on private party values, for cars in good condition with automatic transmission, and standard and identical sets of options. I assume that "normal" or full annual use of the vehicle adds 15,000 miles per year. June 2007 was close to the end of a model year, and a 2006 vehicle in June 2007 already had an average of 20,000 miles on it. Thus the first comparison made is between a 2006 vehicle with 20,000 miles and a 2005 vehicle with 35,000 miles. Annual depreciation is reckoned as the difference at a point in time in the price of the two vehicles. One can then explore how much depreciation is reduced if the car has been operated at 90 percent of "capacity" during the prior year – 13,500 miles as opposed to 15,000, for a total of 33,500 miles on the odometer of the 2005 vehicle. Estimates of reduced depreciation from lower levels of utilization are derived in a similar matter.

In calculating the annual user cost of the vehicle I assume that one buys the vehicle at the start of one year, and sells it twelve months later. The accounting ignores transactions costs as well as operating costs such as gasoline, insurance, and normal maintenance. User cost consists therefore of two parts: depreciation, which is affected by utilization, and the pure holding cost of the asset, which is not (an interest rate of 5 percent is assumed).[13] Because capital stocks will typically consist of assets of different vintages, I average these elasticities across the several vintages to get an overall estimate of the sensitivity of depreciation in an archetypal machine to different levels of utilization.

[13]One might question the absence of cyclical variation to holding cost, although so long as all world economies don't go into recession at the same time (as they appear to be doing in 2009), and capital flows are unrestricted, invariance can perhaps be justified. Minor adjustments in any of the parameters assumed in the analysis will not change the basic conclusions of the paper.

The following example helps elucidate the calculations. The private party value of a 2006 Camry 4DR LE with 20,000 miles in June 2007 was $15,945. Assuming a cost of capital of 5 percent (this was then the approximate opportunity cost of pulling the funds from a risk free Treasury bond), we would have a pure annual holding cost for the vehicle of $797 (.05*15,945). A 2005 model, similarly equipped, with 35,000 miles on the odometer sells for $14,405, giving a depreciation cost of $1,540 for a year's "full" use.

Suppose the vehicle were used 10 percent less. If the mileage on the 2005 car were only 33,500, depreciation would fall to $1,365. If the mileage were 20 percent less, we can estimate depreciation at $1,290, and so on. In the case of a fixed asset relying heavily on mechanical engineering, where friction matters, and with a relatively short service life, lower utilization means a lower service flow, although the effect on total annual user costs is softened by the utilization invariant costs of holding the asset. Averaging across the savings associated with different vintages, we conclude that a 10 percent drop in utilization is likely in this asset category to reduce depreciation by about 13 percent, a 20 percent drop in utilization will reduce depreciation by about 17.7 percent, a 30 percent drop in utilization by about 27.5 percent, and so forth. Subsequently in the paper I will use these numbers as the basis for a capital utilization adjustment for archetypal machines – capital goods similar in their characteristics to automotive vehicles.

(TABLE 2 ABOUT HERE)

The analysis to this point has asserted substantial differences in asset lives between equipment and structures. There are a variety of sources of information on service lives that confirm this intuition. We can start with the IRS's Modified Accelerated Cost

Recovery System (MACRS) a partial summary of which is listed below (US Department of the Treasury, 2006):

3 year property: tractors for over the road use
5 year property: Automobiles, taxis, buses and trucks
computers and peripheral equipment
office machinery: typewriters, copiers, calculators
property used in research and experimentation
breeding and dairy cattle
appliances, carpets, furniture used in rental real estate
geothermal, solar, wind energy property
7 year property: office furniture and fixtures (desks, files, safes)
agricultural machinery and equipment
10 year property: vessels, barges, tugs, similar water transport equipment
single purpose agricultural or horticultural structure
tree or vine bearing fruit or nuts
15 year property: improvements made to land (shrubbery, fences, roads, bridges)
20 year property: farm buildings other than single purpose agricultural or horticultual structures
25 year property: water utility and sewers
27.5 years: residential real property
39 years: commercial real property

Although this information is broadly relevant in terms of which types of assets are considered to have longer useful service lives, the tax treatment of depreciation need not bear a close relationship to true economic depreciation. The IRS does include, however, in its Publication 946, some estimates of what it considers to be actual service lives for different asset categories. These generally correspond to the depreciation periods under the alternative depreciation System (ADS) as opposed to the General Depreciation System (GDS). Depreciation periods (class life) under the ADS are generally longer and seem to correspond more closely to actual economic service life, although there is an exception in the case of automobiles and taxis, which are 5 year property under the GDS but 3 year property under the ADS. Prior to 1981 the IRS required straight line depreciation, and that is still required under the ADS. Under the Economic Recovery Tax Act of 1981 (ERTA) and then again under the Tax Reform Act of 1986 (TRA-86) legislated changes introduced a variety of opportunities for accelerated depreciation. These reflected a decision to use tax policy to subsidize the acquisition of fixed assets, particularly equipment, and more generally to encourage investment and capital accumulation, not necessarily a change in the way the IRS thought assets were actually depreciating.

A second source of information on service lives can be gleaned from the Bureau of Economic Analysis's Fixed Asset Tables. By comparing the current cost depreciation estimates (Table 2.03) with the current cost net stock of capital for different asset categories (Table 2.01), we can extract an implied service life for each asset type under the assumption the BEA statisticians used straight line depreciation. The data are somewhat noisy because the data, particularly depreciation, are subject to rounding and are not reported with high precision. Still, the numbers in Table 3, calculated for various business cycle benchmarks, are broadly consistent with what we would expect: structures have much longer service lives than equipment.

We now have enough data to make an estimate of how much a rise or fall in the output gap might actually influence the aggregate service flow from the capital stock, and therefore how much of a cyclical adjustment might be warranted. In Table 4, I develop this for the year 1929. I begin with a list of the components of the net private capital stock in 1929 from Table 2.01 of the Fixed Asset Tables. The current cost value of the stock in 1929 was $245 billion. Because I am interested in the private nonfarm economy, I have removed farm buildings ($4 billion) and farm machinery ($1.7 billion) from the table.

(TABLE 3 ABOUT HERE)

The pure holding cost (annual) of the remaining stock is then calculated by multiplying it by 5 percent to get $11.97 billion. Actual depreciation on the stock and its components is drawn from Table 2.03 of the Fixed Asset Tables, again removing the lines for farm buildings and agricultural machinery. The assumption is that the economy was operating at capacity in 1929.

I then proceed to calculate alternate depreciation adjustments assuming the economy was 10, 20, 30, 40 or 50 percent below capacity. These calculations are based on different assumptions for each of the four broad asset categories discussed in the text. Both structures and non-archetypal equipment (mostly information processing equipment) are assumed to have depreciation flows unaffected by utilization. Archetypal machinery, in contrast, is heavily affected, and is depreciated according to the set of rates derived from the vehicle data described in Table 2: 13 percent reduction for use at 90 percent of "capacity", 18 percent reduction for use at 80 percent of "capacity" and so forth.

Finally, "hybrid" assets, (mostly transport equipment), which combine some of the cost characteristics of structures and equipment, are assumed to have low but nonzero sensitivity of depreciation to utilization. I've arbitrarily assumed it be one fifth that of archetypal machines. Much of the capacity adjustment for truck, bus, railroad, airline or steamship companies is reflected in reduced load factors, which will have minimal effects on depreciation flows.

From these assumptions, we derive a set of estimates of aggregate depreciation flows for the economy at 90 percent, 80 percent, 70 percent, 60 percent, and 50 percent of capacity (note that these correspond to a departure from full utilization of 10, 20, 30, 40 and 50 percent, respectively). At full utilization (and full capacity) we have aggregate depreciation of $8.2 billion (this is straight from the BEA's Fixed Asset Table 2.03, less agricultural machinery and buildings). For 90 percent utilization, this declines to $7.68 billion, for 80 percent utilization, to $7.52 billion, and so on.

(TABLE 4 ABOUT HERE)

In Table 5, we use the information in Table 4 to calculate aggregate annual user costs of capital in 1929 at different capacity utilization levels. Total user costs are the sum of utilization-invariant holding costs and the variable depreciation flows. Cutting capacity utilization from 100 to 90 percent cuts annual user costs from $20.2 to $19.6 billion, a reduction of 2.7 percent. There are two reasons why a 10 percent cut in utilization cuts annual user costs by only 2.7 percent. First, although the depreciation flows of archetypal equipment are strongly reduced by this cut in utilization, the preponderance of assets in the stock, which is dominated by structures, experience little or no change in their economic depreciation. The impact is further lessened because of the large value and utilization invariance of the annual holding costs (of which $1.6 billion is for the shorter lived equipment and software and $10.36 billion is for structures).

(TABLE 5 ABOUT HERE)

As has been described in the text above, lowering capital input in the trough of a recession will raise the calculated level of TFP, thus weakening or possibly eliminating the finding of procyclicality. But as we have seen, the effect of lower capacity utilization on the aggregate user cost of capital is small, and its impact on the level of TFP is further diminished because of the way the estimate of the capital input enters the calculation.

Assuming Cobb-Douglass production, with a capital share of one third (this is at the high end of historical estimates of capital's share), the level of TFP is calculated as $Y/((K^{1/3})*(N^{.2/3}))$, where Y is output, K is capital input, and N is hours. Thus a 2.7 percent reduction in estimated capital input, for example, will increase the estimated level of TFP by only .9 percent. If the economy is running at 80 percent capacity, we have depreciation dropping 3.5 percent, but TFP rising only 1.2 percent.

How much do these cyclical adjustments threaten the finding of procyclical TFP? The sensitivity analysis is conducted for 1929-1941 because the Depression years experienced the largest shortfalls of output relative to capacity.

The analysis proceeds in this fashion. First, I establish a set of measures of capacity utilization for the US private nonfarm economy from 1929-1941. We assume that the economy was at capacity in 1929, and that potential output grew at a constant rate of 3.5 percent across the twelve year period. Field's latest estimates for TFP growth across the period are of 2.78 percent per year (Field, 2008a); the remaining growth in potential output we can attribute to labor force growth (the growth of capital was negligible over the period). What these assumptions imply, incidentally, is that production in 1933 may have represented even more of a shortfall than has been commonly recognized. One typically calculates how much real output declined relative to 1929 (about a third for the private nonfarm economy), but if one accepts the view that the Depression years were technologically progressive (Field 2003), and assumes constancy in the growth of TFP at potential across the period (admittedly, arbitrarily), one concludes that output may have been as much as 50 percent below potential in 1933. Table 5, column 2, gives my estimates of utilization as a share of potential.

Tables 4 and 5 provide estimates for 1929 of how lowered utilization would affect depreciation flows at 10 percentage point intervals. In Table 6 I use this data, linearly interpolating between the intervals to map the utilization estimates onto an estimate of depreciation as a fraction of what it would be at capacity. For example, for 1930, output is 9.5 percent below 1929 levels but 13.5 percent below capacity (utilization at .865). Based on the previous analysis this would reduce depreciation about 3 percent (depreciation would be 97 percent of what it would have been had the economy been at potential (see column 3). Assuming a capital share of 1/3, we then get a TFP adjustment factor of 1.01 – TFP will be 1 percent higher with a utilization adjustment for capital input than without it. This is multiplied by the TFP index from Kendrick to get an adjusted TFP index.

(TABLE 6 ABOUT HERE)

How vulnerable is the finding of TFP procyclicality to the use of this adjusted TFP index, and thus indirectly to a capital utilization adjustment? Let's start with the equation with which Field (2008a) began,[14] regressing the change in the natural log of TFP on the change in the unemployment rate for the years 1929-1941:

$$\Delta TFP = .0283 \quad - \quad .0092^{*}\, \Delta UR$$

$$(1.1) \qquad R^2 = .647 \quad (3.02) \qquad (-4.28)$$

[14] Field used this regression to make a cyclical adjustment to 1941 TFP. Output was still below potential (unemployment averaged 9.9 percent) in 1941, so the adjustment raised the (full employment) level of TFP in 1941 and thus its rate of growth from 1929 to 1941. Without the adjustment that rate is 2.31 percent per year; with the adjustment it rises to 2.78 percent per year (initial data are from Kendrick, 1961, and apply to the private nonfarm economy). See Field (2008b) for evidence of the persisting procyclicality of TFP from 1890 through 2004, and the stability of the elasticity of TFP growth with respect to changes in the unemployment rate across periods in which the trend growth rate was quite different.

(t statistics in parentheses; data are for 1929-41; n = 12)

Using the adjusted TFP series, we have:

$$\Delta TFPa = .0283 - .0077^{*} \Delta UR$$

(1.2) $R^2 = .585$ (3.12) (-3.75)

(t statistics in parentheses; data are for 1929-41; n = 12)

The estimate of the trend growth rate is unaffected, and the procyclicality coefficient is weakened somewhat, but is still clearly positive and fairly large.

We can compare this as well with a regression based on Solow's TFP numbers from his 1957 article, which use capital stock adjusted by an estimate of the share of the labor force employed:

$$\Delta TFPSOLOW = .0264 - .0050^{*} \Delta UR$$

(1.3) $R^2 = .449$ (3.38) (-2.86)

(t statistics in parentheses; data are for 1929-41; n = 12)

The productivity procyclicality of the Depression years is so robust that even Solow's large and rather crude adjustment can't eliminate it, although it does weaken it.

(TABLE 7 ABOUT HERE)

Table 7 explores whether the changing shares of components of the fixed asset stock over time alter the conclusion that major changes in capacity utilization have only minor impacts on TFP levels in the trough. This table drives home the point that large cyclical swings in capacity utilization have small impacts on the level of TFP in the trough, not enough to seriously impact the conclusion of TFP procyclicality. Although depreciation flows on archetypal machines are heavily influenced by changes in utilization, such equipment is a small fraction of the overall fixed asset stock, the preponderance of which has depreciation flows which are utilization invariant. Impact on TFP levels is further attenuated because user cost also depends on the pure holding cost of an asset, which is unaffected by utilization, and because the calculation of TFP means that a given decline in capital input translates into a rise in the level of TFP which is much smaller in absolute value.

Conclusion

The argument that procyclical TFP is a statistical artifact poses a serious challenge to any interpretation that sees the phenomenon as real and economically meaningful. . The statistical artifact argument stands or falls on the merits of making large cyclical adjustments to capital input. The title of this paper asked whether capital input data should receive a cyclical adjustment. The answer is yes, but a small one. Our intuition that it should be larger comes from thinking of archetypal machines as representative capital goods. They are not representative, and their depreciation behavior, particularly sensitivity to utilization, is also not representative. Because utilizations adjustments should be small, the common practice of proxying capital service flows with estimates of the stock, while not perfectly accurate through all phases of the cycle, is a reasonable procedure, and provides approximations of service flows which are more defensible than those arising using procedures suggested by Solow, Griliches and Jorgenson, Tatom, or Shapiro.

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Table 1
Shares of Net Private Fixed Capital (Current Cost)
United States, 1929-2000

	1929	1941	1948	1973	1989	2000
Information Processing Equipment and Software	0.8	1.1	1.5	2.8	4.8	5.8
Industrial Equipment	4.3	4.8	5.1	6.6	6.9	6.0
Transportation Equipment	6.2	5.3	4.6	4.1	3.7	3.9
Other Equipment	2.4	2.8	3.5	3.9	4.0	3.5
Nonresidential Structures	37.5	36.1	33.9	32.5	31.8	30.4
Residential Structures	48.7	49.9	51.2	49.9	48.6	50.2
Total Structures	86.2	86.0	85.1	82.3	80.4	80.6
Total Private Fixed Assets	100.0	100.0	100.0	100.0	100.0	100.0

Source: www.bea.gov, Fixed Asset Table 2.1, accessed June 10, 2007.

Table 2
Effect of Utilization Differences on Annual User Cost of an Archetypal Machine

	Pure Holding Cost	Depreciation	Reduction in Depr.	Total User Cost	Reduction in user cost (%)
Regular Utilization 2006 - 2005 vehicle*	**$797**	**$1540**		**$2337**	
10 % less utilization	$797	$1365	11.3%	$2162	7.5%
20 % less utilization	$797	$1290	16.2%	$2087	10.7%
30% less utilization	$797	$1115	27.6%	$1912	18.2%
40% less utilization	$797	$ 915	40.6%	$1712	26.7%
50% less utilization	$797	$790	48.7%	$1587	32.1%
Regular Utilization 2005-2004 vehicle	**$720**	**$1775**		**$2495**	
10 % less utilization	$720	$1425	19.7%	$2145	14.0%
20 % less utilization	$720	$1350	23.9%	$2070	17.0%
30% less utilization	$720	$1200	32.4%	$1920	23.0%
40% less utilization	$720	$1150	35.2%	$1870	25.1%
50% less utilization	$720	$ 975	45.1%	$1695	32.1%
Regular Utilization 2004-2003 vehicle	**$632**	**$1555**		**$2187**	
10 % less utilization	$632	$1430	8.0%	$2062	5.7%
20 % less utilization	$632	$1355	12.9%	$1987	9.1%
30% less utilization	$632	$1205	22.5%	$1837	16.0%
40% less utilization	$632	$955	38.5%	$1587	27.4%
50% less utilization	$632	$ 830	46.6%	$1462	33.2%

* Depreciation is based on comparing the cost in June 2007 of a 2006 vehicle with 20,000 miles on it with the price of a similarly equipped 2005 vehicle with 35,000 miles on it. Source: http://www.kbb.com, accessed June 10, 2007. Data are for a Toyota Camry 4DR LE sedan, AT, good condition, private party value. Opportunity cost of capital assumed = 5%; "normal" annual mileage assumed = 15,000.

Table 3
Implied Service Lives (Years) from BEA Fixed Asset Tables

	1929	1941	1948	1973	1989	2000	2005
Private fixed assets	29	31	30	26	22	18	22
Equipment and software	7	8	8	8	7	5	6
Information processing equipment and software	5	6	6	6	5	3	4
Industrial equipment	11	11	12	11	11	10	10
Transportation equipment	6	7	7	7	7	6	7
Other equipment	7	8	8	7	7	6	7
Structures	54	57	55	53	49	38	44
Nonresidential structures	38	40	38	38	35	29	34
Residential structures	80	82	78	72	67	47	53

Source: www.bea.gov, Tables 2.01 and 2.03, accessed June 9, 2007.

Table 4
Estimated Effect on Aggregate User Cost of Capital of Operating Below Potential, United States, 1929
(billions of dollars)

	Reduction in Depreciation at Percent Below Capacity					Net Private Capital Current Cost	Holding Costs at 5 %	Depreciation at percent of capacity					
	10%	20%	30%	40%	50%			100%	90%	80%	70%	60%	50%
Private fixed assets						**239.3**	11.97	**8.2**	7.68	7.52	7.22	6.88	6.59
							0.00						
Equipment and software						**32.1**	1.61	**4.4**	3.88	3.72	3.42	3.08	2.79
							0.00						
Nonresidential equipment and software						**31.7**	1.59	**4.3**	3.78	3.62	3.32	2.98	2.69
							0.00						
Information processing equipment and software						1.9	0.10	0.4	0.27	0.26	0.25	0.22	0.21
Computers and peripheral equipment	0%	0%	0%	0%	0%	0.0	0.00	0.0	0.00	0.00	0.00	0.00	0.00
Software	0%	0%	0%	0%	0%	0.0	0.00	0.0	0.00	0.00	0.00	0.00	0.00
Communication equipment	0%	0%	0%	0%	0%	1.0	0.05	0.1	0.10	0.10	0.10	0.10	0.10
Medical equipment and instruments	0%	0%	0%	0%	0%	0.2	0.01	0.0	0.00	0.00	0.00	0.00	0.00
Nonmedical instruments	0%	0%	0%	0%	0%	0.1	0.01	0.0	0.00	0.00	0.00	0.00	0.00
Photocopy and related equipment	13%	18%	28%	38%	47%	0.1	0.01	0.0	0.00	0.00	0.00	0.00	0.00
Office and accounting equipment	13%	18%	28%	38%	47%	0.6	0.03	0.2	0.17	0.16	0.15	0.12	0.11
Industrial equipment	13%	18%	28%	38%	47%	10.5	0.53	1.0	0.87	0.82	0.73	0.62	0.53
Fabricated metal products	13%	18%	28%	38%	47%	1.0	0.05	0.1	0.09	0.08	0.07	0.06	0.05
Engines and turbines	13%	18%	28%	38%	47%	0.7	0.04	0.1	0.09	0.08	0.07	0.06	0.05
Metalworking machinery	13%	18%	28%	38%	47%	1.4	0.07	0.1	0.09	0.08	0.07	0.06	0.05
Special industry machinery, n.e.c.	13%	18%	28%	38%	47%	3.7	0.19	0.4	0.35	0.33	0.29	0.25	0.21
Gen. industrial, incl. materials handling eq.	13%	18%	28%	38%	47%	2.3	0.12	0.2	0.17	0.16	0.15	0.12	0.11
Electrical transmission, distrib., industrial app.	13%	18%	28%	38%	47%	1.4	0.07	0.1	0.09	0.08	0.07	0.06	0.05
Transportation equipment						15.2	0.76	2.4	2.20	2.12	1.99	1.82	1.68
Trucks, buses, and truck trailers						2.6	0.13	0.5	0.49	0.49	0.50	0.49	0.49

Light trucks (including utility vehicles)	2%	3%	5%	7%	9%	1.5	0.08	0.3	0.29	0.29	0.29	0.28	0.27
Other trucks, buses, and truck trailers	2%	3%	5%	7%	9%	1.1	0.06	0.2	0.20	0.19	0.19	0.19	0.18
Autos	13%	18%	28%	38%	47%	4.0	0.20	1.4	1.22	1.15	1.02	0.87	0.74
Aircraft	2%	3%	5%	7%	9%	0.1	0.01	0.0	0.00	0.00	0.00	0.00	0.00
Ships and boats	2%	3%	5%	7%	9%	2.1	0.11	0.1	0.10	0.10	0.10	0.09	0.09
Railroad equipment	2%	3%	5%	7%	9%	6.5	0.33	0.4	0.39	0.39	0.38	0.37	0.36
Other equipment						4.1	0.21	0.6	0.44	0.41	0.36	0.31	0.27
Furniture and fixtures	13%	18%	28%	38%	47%	1.9	0.10	0.2	0.17	0.16	0.14	0.12	0.11
Construction machinery	13%	18%	28%	38%	47%	0.4	0.02	0.1	0.09	0.08	0.07	0.06	0.05
Mining and oilfield machinery	13%	18%	28%	38%	47%	0.7	0.04	0.1	0.09	0.08	0.07	0.06	0.05
Service industry machinery	13%	18%	28%	38%	47%	0.9	0.05	0.1	0.09	0.08	0.07	0.06	0.05
Electrical equipment, n.e.c.	13%	18%	28%	38%	47%	0.0	0.00	0.0	0	0.00	0.00	0.00	0.00
Other nonresidential equipment	13%	18%	28%	38%	47%	0.1	0.01	0.0	0	0.00	0.00	0.00	0.00
							0.00			0.00	0.00	0.00	0.00
Residential equipment	0%	0%	0%	0%	0%	**0.4**	0.02	**0.1**	0.1	0.10	0.10	0.10	0.10
			0%	0%	0%		0.00			0.00	0.00	0.00	0.00
Structures	0%	0%	0%	0%	0%	**207.2**	10.36	**3.8**	3.8	3.80	3.80	3.80	3.80
			0%	0%	0%		0.00			0.00	0.00	0.00	0.00
Nonresidential structures	0%	0%	0%	0%	0%	**87.8**	4.39	**2.3**	2.3	2.30	2.30	2.30	2.30
			0%	0%	0%		0.00			0.00	0.00	0.00	0.00
Commercial and health care	0%	0%	0%	0%	0%	16.0	0.80	0.4	0.4	0.40	0.40	0.40	0.40
Commercial, including office	0%	0%	0%	0%	0%	15.0	0.75	0.4	0.4	0.40	0.40	0.40	0.40
Office, including medical buildings	0%	0%	0%	0%	0%	4.0	0.20	0.1	0.1	0.10	0.10	0.10	0.10
Commercial	0%	0%	0%	0%	0%	11.0	0.55	0.3	0.3	0.30	0.30	0.30	0.30
Hospitals and special care	0%	0%	0%	0%	0%	1.0	0.05	0.0	0.0	0.00	0.00	0.00	0.00
Manufacturing	0%	0%	0%	0%	0%	11.4	0.57	0.4	0.4	0.40	0.40	0.40	0.40
Power and communication	0%	0%	0%	0%	0%	13.8	0.69	0.3	0.3	0.30	0.30	0.30	0.30
Power	0%	0%	0%	0%	0%	11.0	0.55	0.3	0.3	0.30	0.30	0.30	0.30
Electric	0%	0%	0%	0%	0%	7.1	0.36	0.2	0.2	0.20	0.20	0.20	0.20
Other power	0%	0%	0%	0%	0%	3.9	0.20	0.1	0.1	0.10	0.10	0.10	0.10
Communication	0%	0%	0%	0%	0%	2.8	0.14	0.1	0.1	0.10	0.10	0.10	0.10
Mining exploration, shafts, and wells	0%	0%	0%	0%	0%	4.2	0.21	0.2	0.2	0.20	0.20	0.20	0.20

Petroleum and natural gas	0%	0%	0%	0%	0%	3.8	0.19	0.2	0.2	0.20	0.20	0.20	0.20
Mining	0%	0%	0%	0%	0%	0.3	0.02	0.0	0.0	0.00	0.00	0.00	0.00
Other structures	0%	0%	0%	0%	0%	42.5	2.13	1.1	1.1	1.10	1.10	1.10	1.10
Religious	0%	0%	0%	0%	0%	2.1	0.11	0.0	0.0	0.00	0.00	0.00	0.00
Educational	0%	0%	0%	0%	0%	1.1	0.06	0.0	0.0	0.00	0.00	0.00	0.00
Other buildings	0%	0%	0%	0%	0%	8.0	0.40	0.2	0.2	0.20	0.20	0.20	0.20
Railroads	0%	0%	0%	0%	0%	27.0	1.35	0.6	0.6	0.60	0.60	0.60	0.60
Other	0%	0%	0%	0%	0%	4.3	0.22	0.1	0.1	0.10	0.10	0.10	0.10
Residential structures	0%	0%	0%	0%	0%	**119.4**	5.97	**1.5**	1.5	1.50	1.50	1.50	1.50
Housing units	0%	0%	0%	0%	0%	110.2	5.51	1.3	1.3	1.30	1.30	1.30	1.30
Permanent site	0%	0%	0%	0%	0%	110.2	5.51	1.3	1.3	1.30	1.30	1.30	1.30
1-to-4-unit	0%	0%	0%	0%	0%	100.0	5.00	1.1	1.1	1.10	1.10	1.10	1.10
5-or-more-unit	0%	0%	0%	0%	0%	10.1	0.51	0.1	0.1	0.10	0.10	0.10	0.10
Manufactured homes	0%	0%	0%	0%	0%	0.0	0.00	0.0	0.0	0.00	0.00	0.00	0.00
Improvements	0%	0%	0%	0%	0%	7.9	0.40	0.2	0.2	0.20	0.20	0.20	0.20
Other residential	0%	0%	0%	0%	0%	1.3	0.07	0.0	0.0	0.00	0.00	0.00	0.00

Sources: Table 2, www.bea.gov, Tables 2.01 and 2.03; see text.

Table 5
Effect of Capacity Utilization Adjustment on TFP, 1929 data

Capacity	100%	90%	80%	70%	60%	50%
User Costs of Capital	$20.2	$19.6	$19.5	$19.2	$18.8	$18.6
User Costs as % of Costs at Full Capacity	1..000	0.973	0.965	0.950	0.933	0.919
TFP (level)	1.000	1.009	1.012	1.017	1.023	1.029

Sources: Table 4; see text.

Table 6
Effect of a Capital Stock Utilization Adjustment on TFP Growth in the US Private Non Farm Economy, 1929-1941

	1	2	3	4	5	6
Year	Output	Utilization	Depreciation	TFP adj.factor	TFP	Adj TFP
1929	100.0				100.0	100
1930	90.5	0.865	0.97	1.010	96.5	97.5
1931	81.5	0.725	0.958	1.014	95.3	96.7
1932	68.5	0.517	0.92	1.028	90.5	93.1
1933	66.0	0.444	0.91	1.032	88.7	91.5
1934	75.6	0.545	0.924	1.027	101.2	103.9
1935	82.2	0.594	0.931	1.024	105.9	108.5
1936	94.9	0.703	0.95	1.017	112.6	114.5
1937	100.9	0.729	0.954	1.016	114.4	116.2
1938	94.1	0.624	0.937	1.022	115.0	117.5
1939	103.8	0.687	0.948	1.018	119.4	121.5
1940	110.8	0.718	0.953	1.016	122.4	124.4
1941	132.3	0.860	0.97	1.010	132.0	133.3

Sources: Columns 1, 5: Kendrick, 1961. Columns 2, 3, 4, 6: Tables 4 and 5; see text.

Table 7
Percent Increase in TFP if Capital Input is Cyclically Adjusted

	1929	1941	1948	1973	1989	2000
10 percent below capacity	.93	.81	.81	.85	.86	.59
20 percent below capacity	1.21	1.05	1.13	1.18	1.18	.81
30 percent below capacity	1.72	1.34	1.71	1.81	1.80	1.22

Note that .93, for example, means less than 1 percent.
Source: Tables 4-6; see text.