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The Equipment Hypothesis and U.S. Economic Growth

by

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ABSTRACT

In several articles published in the 1990s, de Long and Summers argued that investment in producer durables had a high propensity to generate externalities in using industries, resulting in a systematic and substantial divergence between its social and private return. They maintained, moreover, that this was not the case for structures investment. Together, these claims constitute the equipment hypothesis. This paper explores the degree to which the history of U.S. economic growth in the twentieth century supports it.

The Equipment Hypothesis and U.S. Economic Growth

Introduction

Equipment – producer durables – has long enjoyed a privileged position in thinking about economic growth, in spite of the fact that throughout most of recorded economic history its importance has been dwarfed by structures both in flows of net investment and in shares of the capital stock (Field, 1985). Machinery, with its roots in mechanical and electrical engineering, its intricacies, its interplay of finely wrought moving or changing parts, may simply be more interesting than structures to the typical economist.

But there is a serious economic argument as to why we should pay special attention to machinery. Many scholars believe that machinery, unlike structures, is an important carrier of or stimulus for the type of technological change that shows up in measures of total factor productivity growth. This means that machinery is particularly likely to generate uncompensated spillover effects in using sectors – uncompensated in the sense that the producers of the machinery do not reap the full benefit of the incremental contribution to value added for which their product is responsible. These contributions can be thought of as the consequence of positive production externalities.

Another way of stating this is that there is a divergence between the private and social return to investment in machinery, which in turn leads to the conclusion that tax policies favoring equipment (investment credits, accelerated depreciation schedules) are desirable. If growth is the objective, it follows that equipment investment should be subsidized, either directly or through tax policy, and organizations contributing to the formation of different types of capital should not face a level playing field. In particular, those producing equipment, and their customers, should be favored.

The equipment hypothesis has deep roots in classic works in economic theory which placed great emphasis on the productivity implications of mechanical innovations, particularly in manufacturing. It received renewed attention in the early 1990s as the result of a series of papers by De Long and Summers (De Long and Summers, 1991, 1992; De Long 1992). Although these papers are often understood to be concerned primarily with developing economies, the authors viewed their conclusions as as applicable to developed countries as to those aspiring to become so. It is appropriate, therefore, to reexamine what the economic history of the world's largest developed economy tells us about the hypothesis.

The Modern Statement of the Equipment Hypothesis

De Long and Summers' 1991 article reported the results of cross country regressions on data from 61 countries over the years 1960-1985. These regressions showed a statistical relationship between the share of equipment investment in GDP and the rate of growth of output per hour. Based on these data, they maintained that

> … the social rate of return on equipment investment is 30 percent per year, or higher. Much of this return is not captured by private investors…. The gains from raising equipment investment through tax or other incentives dwarf losses from any nonneutralities that would result. A 20 percent wedge between the social return to equipment and other investments has implications for all policies affecting saving and capital allocations (1991, p. 485).

This passage contains two empirical claims and a policy implication: that the social return to equipment investment is high, that it is largely uncompensated, and that it warrants subsidization. Elsewhere in the paper De Long and Summers make clear their view that this 30 percent social return applies to advanced as well as developing economies,[1] and their belief in an asymmetry between the effects on growth of equipment investment as opposed to investment in structures.[2]

The De Long and Summer analysis, as well as that of this paper, is developed within the context of a version of the Solow growth model and the growth accounting tradition with which it is associated (Abramovitz, 1956; Solow, 1957). De Long and Summers maintained that some types of investment – equipment investment -- contributed to the growth of the residual in a way that investment in structures did not. They intended their work as a counter to the "investment pessimism" implied by the original Abramovitz and Solow analyses which attributed a substantial portion of growth to factors other than inputs conventionally measured. If Abramovitz and Solow were right, then one couldn't necessarily expect much boost to economic growth from boosting saving rates and physical capital accumulation.

The De Long and Summers analysis implied that while this pessimism might be warranted for the accumulation of structures, it was not so for equipment. Within the standard growth accounting framework, focusing only on the rate of equipment accumulation (weighted by its share in national income) would understate the contribution to growth of such investment because it would not take into account the role of new producer durables in generating positive production externalities, which would also be responsible for part of the increase of the residual. This double barreled impact on growth was not applicable, in contrast, to that portion of capital accumulation associated with investment in structures.

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[1] "We interpret our results as suggesting that the social return to equipment investment in well functioning market economies is on the order of 30 percent per year" (De Long and Summers, 1991, p. 446).

[2] "We see no reason to expect that investments in structures should carry with them the same external effects as plausibly attach to investments in equipment" (1991, p. 480).

In 1992, following additional empirical work, De Long and Summers reduced their estimate of the social rate of return to equipment investment from 30 to 20 percent, but reaffirmed the earlier conclusions, and in particular the applicability of these conclusions to advanced countries such as the United States.[3] Even if the estimated wedge between the total return to equipment investment and that of other investments had been 10 rather than 20 percentage points, this would still have been a very large wedge.[4] If the spillover effects were as large as De Long and Summers suggested, they would have justified far more than a "modest" bias toward equipment investment. If we truly believed these numbers, the government should have been sending out checks – and they should have been large -- to firms and perhaps even households installing more equipment. Obviously, there are companies, including many in Silicon Valley, who would have found this a very congenial policy.

De Long and Summers wrote at the start of the 1990s, at the beginning of the longest economic expansion in U.S. economic history. During this boom, the U.S. experienced a continued decline in the relative price of equipment, led by the operation of Moore's law in computers and semiconductors, and a surge in physical capital formation coinciding with a rising share of equipment in gross and net capital formation and in the capital stock. Finally, after 1995, this was matched by an acceleration in both labor and

[3] "Growth -- measured by labor or by TFP – is as tied to high equipment investment for rich countries as it it for newly industrializing ones…. Equipment investment appears to have a very high net social return – in the range of 20 percent per year; more than half of this comes from increased TFP. We conclude that the macroeconomic data give no evidence that poorer countries benefit more from high rates of equipment investment than do richer countries. This suggests, significantly, large external benefits from equipment investment, even in rich economies. We conclude that policies that tilt the playing field against equipment investment are likely to be disastrous and that a strong case exists for at least a modest bias in favor of equipment investment (De Long and Summers, 1992, p. 159).

[4] A 10 percentage point decline in one year in the estimated social return to equipment investment is quite remarkable in itself. Note that De Long (1992, p. 322) interpreted his longitudinal – cross sectional analysis of advanced economy growth as suggesting a rate of return to machinery investment of over 50 percent per year or more, returns that "dwarf the profits that investors in the capital goods are able to appropriate directly." He acknowledged, however, that this estimate might be too high.

total factor productivity growth (see Field, 2006a). From the vantage point of 2000, with the NASDAQ approaching its all time high, the coincidence of rising equipment investment and an increase in the growth rate of the residual appeared to confirm the validity of the equipment hypothesis, as well perhaps as justify stratospheric stock valuations.

But the NASDAQ remained only briefly at its March high of 5,048, and more than five year out from the end of the boom – remained at more modest levels.[5] There is now greater receptivity to a more nuanced view of the impact of IT investment. It is certainly possible that the information technology revolution may still have its best days ahead. But the deflation of tech stock prices, and the memories of the hype associated with their inflation, are reminders that we are perhaps better served by focusing more attention on what has in fact happened and can be documented in the data, as opposed to what we believe may happen, or hope will happen.

What Can We Learn from the Economic History of the United States?

Many analyses of recent productivity advance, if they look back in history at all, do so no further than 1948, the start date for the productivity series maintained by the Bureau of Labor Statistics. This paper, as does De Long and Summers 1992 and De Long 1992, takes a longer view, with particular focus in my case on the interwar period. It argues, based on a reconsideration of the patterns of economic growth, investment, and technical change in the United States between 1919 and 2000, that the social returns to equipment investment claimed as a general principle by De Long and Summers are too high. And it argues that the claimed asymmetry between the ability of equipment as opposed to structures investment to generate TFP growth is not supported by the

[5] In the Fall 2005, the NASDAQ remained remained at roughly 40 percent of its peak value.

historical record. The rise in equipment investment and its share of total investment in the United States represents a trend that has been proceeding steadily since the end of the Second World War. It has coincided, rather surprisingly, with a long term downward trend in TFP growth, as the economy moved away from the very rapid advances registered for the private nonfarm economy during the interwar period.

Unlike some of the IT prophets who emerged later in the 1990s, the De Long and Summers work was based on quantitative analysis, not anecdotal evidence. De Long and Summers (1991) examined data for 61 countries over the period 1960-85. De Long and Summers (1992) extended the cross country investigation backward to 1950 and forward to 1990. De Long (1992) analyzed a pooled cross section time series[6] analysis of six advanced countries extending back to 1870.

My purpose here is not to provide a comprehensive critical analysis of the post 1950 econometric work and its interpretation, which has already been done by others. Auerbach, Hasset, and Oliner (1994), for example, argued that the 1991 DeLong and Summers results were statistical artifacts resulting from the inclusion of outliers (particularly the diamond mining country of Botswana, which had the highest equipment to GDP ratio). More generally, the critics argued, it was inappropriate to include high income, low income and newly industrializing economies in the same regression, since not all of these countries had access to the same production possibilities as advanced nations; many indeed were in the process of moving toward that access. Most importantly, Auerbach et al questioned the relevance of the conclusions for the United States: in particular that equipment warranted special tax treatment because the spillovers meant that it had a higher social than private return. De Long (1992), which

[6] The time series are series of growth rates over specified business cycle intervals.

examined the performance of six advanced countries over more than a century, can be seen in part as an anticipatory response to the type of objections raised by Auerbach et. al.

My interest is in what countries aspiring to be developed can learn from the economic history of the world's largest and most important twentieth century economy, and in how our history should inform tax policies in advanced countries. In 1992, De Long and Summers wrote that "… in assessing the determinants of growth, there is little alternative to examining natural experiments provided by the different policies, investment outcomes, and growth rates found in various different nations" (1992, p. 158). This paper explores the lessons to be learned from the natural experiments provided in different time periods in the twentieth century in the United States.

De Long also undertook longitudinal analysis. His 1992 paper examined advanced performance in six countries over eight time intervals spanning the years 1870 to 1980: 1870 to 1885, 1885 to 1900, 1900 to 1913, 1913 to 1929, 1929 to 1938, 1938 to 1950, 1950 to 1965, and 1965 to 1980. He acknowledged a goal of examining growth rather than cyclical phenomenon, remarking that "the 15 year frequency of observation, with some dates offset to better match the cycle and the eras of war and peace, was chosen to reveal long run shifts in growth rates instead of short run cyclical fluctuations" (De Long, 1992, p. 309).

The standard in growth accounting is to restrict growth rate calculations as closely as possible to peak to peak measures. The choice of start and stop dates for calculations of growth rates is quite important because of the well known and sometimes quite powerful cyclical influences on productivity advance. At least with respect to the United

States, and probably for other countries, De Long's intervals deviate substantially from this standard. It is largely by accident that many of his beginning and end points are business cycle peaks.

The choice of 1938 as a benchmark date is particularly unfortunate. Unemployment in the United States in 1938 was 19.1 percent, the worst performance in the entire twentieth century save 1932-35. 1929 to 1938 is therefore a peak to trough calculation, and 1938 to 1950 approximately a trough to peak calculation.[7] The choice of beginning and end points makes a *big* difference in productivity growth calculations. TFP growth in the private nonfarm economy between 1929 and 1938 was 1.55 percent per year, as compared with an unadjusted rate of 2.31 percent per year between 1929 and 1941 (Field, 2003, 2005b, 2006a, 2006b).[8] 1938 to 1948 growth was 2.28 percent per year (even higher to 1950, the end year used by De Long), as opposed to the 1.29 percent per year one measures between 1941 and 1948 (see Field, 2003; Kendrick, 1961, Table A-XXIII). The fact that Maddison chose 1938 as a break point in many of his calculations, perhaps because of availability of data in a variety of countries, and the fact that it was the last year before war in Europe, cannot be grounds for ignoring these cyclical influences, particularly in analyses of the economic history of the United States.

Six Peak to Peak Episodes, 1919-2000

In this work I analyze six peak to peacetime peak periods in U.S. economic history for which relatively complete data can be obtained: 1919-1929, 1929-1941, 1941-1948, 1948-1973, 1973-1989, and 1989-2000. Most of the beginning and end dates will be

[7] 1948 is a more appropriate peak for the U.S.; unemployment was 3.8 percent, as compared with 5.3 percent in 1950.

[8] Because productivity growth was strongly procyclical during the Depression years, a cyclical adjustment to the 1941 level raises the estimated TFP growth rate between 1929 and 1941 and, correspondingly, lowers it between 1941 and 1948. See Field (2005b) for full discussion.

familiar to students of U.S. economic history. A few of them warrant further comment. Starting with the most recent period and working backward, 1989 was the last full year of expansion before the downturn; the same was true for 2000. Many analysts of the recent productivity boom prefer to measure from 1995 to 2000, because there was a clear break in the series at mid decade, and it makes the acceleration of productivity growth at the end of the century look somewhat more dramatic. In Table 1 below I also report growth over this shorter period, although it is questionable whether we should be choosing our time intervals with the objective of putting IT in its most favorable light.

The period 1973-89 was of course the dark age of twentieth century U.S. growth, a sixteen year period in which the residual all but disappeared. In contrast, 1948-73 was the golden age of labor productivity growth and living standard advance, during which output per hour in the private nonfarm economy grew at a continuously compounded rate of almost 3 percent per year, the arithmetic consequence of a still respectable rate of TFP advance and a revival (in comparison with the Depression period) of robust rates of capital accumulation and deepening.

The choice of 1941 as a benchmark deserves further comment. A number of economists have noted that it was the second quarter of the century that exhibited the highest rates of TFP growth in this country (Abramovitz and David, 1999; Gordon, 2000b). When growth accounting studies began, all that was then available for the twentieth century were data for its first two quarters. In his 1957 article Solow analyzed data from 1909 to 1949, and the data underlying Abramovitz (1956) also extended for obvious reasons only through the first half of the century. High TFP growth between 1929 and 1948 underlay the Abramovitz/Solow conclusion that, in contrast with the nineteenth century, a large gap had opened up in the twentieth century between the growth of real output and the growth of inputs conventionally measured. The large role of the residual was assumed a distinguishing feature of twentieth century growth in comparison to the nineteenth, and was expected to persist. It did, at reduced rates, for another quarter of a century, but then almost disappeared from view after 1973.

The remarkable 1929-48 TFP performance has almost uniformly been credited to innovation and learning by doing during the Second World War (see, e.g, Abramovitz, 1986, p. 395). I have argued instead that most of the foundations for postwar prosperity were already in place by 1941 (Field, 2003, 2005b.) Simon Kuznets was probably the first fully to appreciate by exactly how much potential output had expanded during the Depression when he was tasked with estimating the U.S. economy's production capacity in preparation for war mobilization. The rise in capacity between 1929 and 1941 made it possible to place more than twelve million individuals in the active duty military, produce very large quantities of military material, and, by some measures, raise real consumption levels in the U.S. relative to Depression levels in spite of rationing and the unavailability of a number of consumer durables.

The expansion of natural output prior to full scale war mobilization, not the experience of the war itself, established most of the foundations for postwar prosperity. At the same time it widened the gap between productivity levels in the U.S. in comparison with Europe or Japan. The successful exploitation of that gap, in turn, helps account for the very high postwar growth rates in those countries (Abramovitz, 1986)

Ideally, as noted, we would like to restrict our growth calculations to peak to peak measures. 1941 is the closest we come to full employment before full scale war mobilization. Unemployment was still 9.9 percent, as compared with 3.2 percent in 1929. In retrospect, it would have been helpful for the purposes of my argument had the attack on Pearl Harbor been delayed by eight to twelve months, so that the U.S. economy could have continued its then rapid return to full employment prior to mobilization. But as a peacetime peak to peak measure, 1941 is superior to 1937, the year that Kendrick used for his benchmark calculations, with 14.3 percent unemployment, and it is superior to 1940, at 14.6 percent unemployment. And it is far superior to 1938, with its 19 percent unemployment rate.

Empirical Analysis

Table 1 below reports TFP growth, output per hour growth, and output per adjusted hour growth for each of the six periods identified.[9] The pre-1948 numbers are calculated from appendices in Kendrick (1961) – the starting point for all modern work on the first half of the century. Post 1948 growth rates are calculated from data available on the Bureau of Labor Statistics website. In Field (2003, 2005a,b and 2006a,b) I discuss some of the sectoral underpinnings of these growth rates in different time periods, as well as some of the qualifications one must make in interpreting estimates of TFP growth.

TABLE 1 ABOUT HERE

For the purposes of this paper, we can focus on the numbers themselves rather than the nuances in their interpretation, since the equipment hypothesis claims, without a great deal of nuance, that high rates of equipment investment will be associated with high rates of TFP growth. While, for given rates of capital deepening, higher TFP growth rates will mean higher growth in output per hour, it makes more sense in evaluating the hypothesis

[9] A comparison of the second and third column of Table 1, which adjusts labor input to take account of quality changes, provides a rough measure of the significance of human capital changes in accounting for the change in output per hour.

to focus on TFP directly, rather than the output per hour or output per capita measures that are the dependent variable in the DeLong and Summers studies. As Figure 1 (based on data in the first column of Table 1) makes visually apparent, for the last eighty years of the twentieth century, TFP growth rates in the United States trended generally downward.

FIGURE 1 ABOUT HERE

To consider the applicability of the equipment hypothesis to U.S. economic experience, we now need to examine relative and absolute trends in equipment capital formation. For these purposes, I have constructed series for the real net stock of both equipment and structures from data in the Bureau of Economic Analysis' Fixed Asset Tables. These tables contain the most authoritative numbers available for the United States private and public capital stock and its components.[10]

The BEA provides estimates in current dollars of components of private and government capital stocks from 1925 onwards. It also provides chained index numbers for the components of the real net stock starting in 1925. From these index numbers, growth rates of the individual components can be calculated. And from the current dollar estimates of the net stocks, ratios of components can be constructed for any particular year. But since these ratios are based on current year prices, their use presents problems if comparisons are made over time. For example, if the real net stock of structures is growing at a steady rate but real equipment investment (and the net stock) is growing more rapidly during a period in which the relative price of equipment is falling, one could

[10] For reasons that are mystifying the BEA no longer makes them easily accessible, but as of late 2005, they could still be accessed at http://www.bea.doc.gov/bea/dn/FAweb/Index2002.htm.

in principle register no change in the current dollar ratio of the net stocks of the two components.

To address this problem, I start with chained indexes, and rescale them using multiplicative constants so that the 1925 index (rather than 1996) equals 100. I then obtain series for the real net equipment and structures stock as the product of this transformed index number and the 1925 current dollar start value. Because the growth of the chain index between two years is based on a geometric average of the differences in levels calculated using current and prior year prices, it provides a measure intermediate in value between a Laspeyres and a Paasche index of growth of an asset component. It provides a reasonable solution to the index number problem in an environment when the relative prices of some components of the Fixed Asset stock, such as equipment, were falling. [11]

FIGURE 2 ABOUT HERE

Figure 2 plots the logged value of the real net stocks of the main components of private nonresidential fixed assets. A first conclusion is that there is no clear trend in the equipment stock between 1925 and 1944. The real net stock of equipment rose moderately between 1925 and 1929, declined sharply through 1935, and then rose moderately through 1944. The net equipment stock was lower in 1941 than it was in 1929.

[11] A real growth rate calculated using a Laspeyres price index, using base period prices, will arguably overstate rates of increase when some components are declining in price and increasing in quantity; a Paasche index using end period prices will arguably understate real growth in the same situation. This is the basic index number problem. A Fisher chained volume index is a geometric average of a Laspeyres real volume index and a Paasche real volume index. That is, it multiplies the two indexes together and takes the square root of their product.

Starting in 1945 and continuing through the end of the century, the equipment stock has grown, sharply between 1945 and 1948 as GOPO (government owned, privately operated) equipment capital was sold off to the private sector, more slowly through 1962, more rapidly through 1980, somewhat more slowly through 1992, and then somewhat more rapidly again through 2001. These accelerations and decelerations are minor, however, compared with the main feature of this series: the absence of trend between 1925 and 1944 followed by steady rise at a rate of 5.01 percent per year thereafter. Figure 2 establishes that the accelerated growth of the equipment stock, both absolutely and as a share of private fixed capital, was not a new development in the 1990s, but rather represented continuation of a trend that began as the Second World War came to an end.

The real net stock of structures series traces out a similar pattern, although the post World War II growth is less than half as rapid: 2.43 percent per year between 1945 and 2001. The real net stock of private nonresidential structures rose between 1925 and 1931, and then trended downward slightly through 1945, before also embarking on its relatively steady growth path after the war, albeit one that was more moderate in comparison with that exhibited by equipment. These different growth rates are, of course, the cause of the rise in the ratio of equipment to structures in the postwar period.

TABLE 2 ABOUT HERE

Using the data summarized in Table 2 we can explore the two propositions that lie at the core of the equipment hypothesis. The first is a claim of a positive relationship between the growth of the real net equipment stock and the growth of total factor productivity.[12]

FIGURE 3 ABOUT HERE

Figure 3 is a scatter plot of the data in columns 1 and 2 of Table 2 (for the 1919-29 period, I can only calculate the annual rate of growth of the equipment stock from 1925 on). If one takes a quick look at the data in Figure 3, one might say that its closest resemblance is to a very large question mark, and that is what the data underlying it suggest with respect to the equipment hypothesis. The highest rate of TFP growth (1929-41) coincides with growth in the real equipment stock. The period exhibiting the highest rate of growth of the real equipment stock, 1941-48, the consequence of a huge government financed infusion of machine tools and other equipment,[13] shows substantially lower TFP growth than the interwar period in its entirety, and much lower growth than the twelve year period immediately preceding, when equipment growth was negative. What ultimately underlies the lack of a positive relationship in the scatter plot is the fact that the upward movement in real equipment investment, which began after the Second World War, and is evident in Figure 2, coincided with the downward drift in TFP growth for the private nonfarm economy evident in Figure 1.

The lack of a positive relationship in Figure 3 is confirmed econometrically. Since the units of analysis here are periods, and since the data points reflect growth rates over these periods, there are only six observations for each of these scatter plots. If one

[12] De Long and Summers state that the hypothesis involve rates of gross equipment investment and growth in output per hour, but it is impossible to have an increase in the real net stock without persisting flows of gross investment. Changes in the stock will obviously be closely related to levels of the flows.
[13] This equipment was initially in GOPO (Government Owned, Privately Operated) plants. But by 1948 it was largely under private ownership, the major exception being synthetic rubber capacity, which was kept in government hands until the mid 1950s.

regresses TFP growth on the growth of the real equipment stock, the coefficient on growth of the equipment stock is negative, although insignificantly different from 0:

$$\text{TFPGROWTH} = 2.17 - .193 * \text{EQGROWTH}.$$

$R^2 = .26$; n = 6 (3.20) (-1.21) (t stats in parentheses)

I am not arguing that this equation shows that more rapid growth of the equipment stock negatively impacts TFP growth. I am arguing that there is absence of evidence of a systematic positive relationship in this data, which reflects eight decades of twentieth century U.S. economic history.

Another interpretation of the equipment hypothesis would suggest the need to correct for growth in the overall size of the economy: According to this interpretation, TFP growth should advance more rapidly when high levels of equipment investment cause the growth of the net stock to exceed the growth of real output. Column 4 of Table 2 shows the results of subtracting the growth rate of private nonfarm economy output (column 3) from the growth rate of the real net equipment stock (column 2), in other words the growth rate of the equipment/output ratio. Figure 4 plots the relationship of this measure to TFP growth.

FIGURE 4 ABOUT HERE

The data reflect the fact that the interwar years, and particularly 1929-41, were years in which the capital output ratio fell, and this was true for equipment capital as well as the fixed capital aggregate (another way of looking at it is that these were years of sharp increases in capital productivity). The absence of a positive relationship between this measure of equipment investment and TFP growth is even more apparent than was the case in Figure 3. Regressing the TFP growth rate on the rate of growth of the equipment to output ratio yields a negative coefficient on the right hand variable although, with five degrees of freedom, it is not quite statistically significant.[14]

TFPGROWTH = 1.63 - .331 * EQ/OUTPUTGROWTH.

R^2 = .57; n = 6 (6.67) (-2.32) (t stats in parentheses)

The Asymmetry Claim

The second key element of the equipment hypothesis is the asserted asymmetry between the respective abilities of growth in the equipment and the structures capital stock to stimulate total factor productivity growth. Column 5 of Table 2 reports, for each of the six periods in question, the average ratio of equipment to structures over the period. These are calculated using the series on real net stocks of equipment and structures whose generation is described above (again, I can only use 1925-1929 for the 1919-29 period). Figure 5 is a scatter plot of these data. Once again, there is an absence of a positive relationship between the average equipment to structures ratio and TFP growth in the private nonfarm economy:

TFPGROWTH = 2.48 - .176 * EQ/STRUCTAVG.

R^2 = .66; n = 6 (5.88) (-2.81) (t stats in parentheses)

Here there is modest evidence of a negative relationship. The lowest ratio of equipment to structures occurs during the period of highest TFP growth (1929-1941). The highest ratio of equipment to structures (1989-2000) is associated with the second lowest TFP growth rate.

[14] One might argue that it takes substantial time for equipment investment to affect TFP growth rates. But the relationship between TFP growth and growth rates of the equipment capital stock (Figure 3) or the equipment/structures ratio (Figure 4) and one period later are no more favorable to the equipment hypothesis.

FIGURE 5 ABOUT HERE

De Long and Summers "see no reason to expect that investments in structures should carry with them the same external effects as plausibly attach to investments in equipment" (1991, p. 480). But they don't provide evidence in support of this assertion – it is assumed to be so obvious as not to require any. Innovations in building design can, however, have significant impacts on within plant productivity, perhaps most notably in the United States during the 1920s in manufacturing.

During that period the net stock of private nonresidential structures was more than three times that of private equipment, and the revolution in factory design associated with the extraordinary TFP gains within manufacturing (5.12 percent per year between 1919 and 1929), depended upon investments in new single story factory structures. Although some of the contemporaneous TFP gains could be indirectly linked to prior advances in electric power generating machinery, much was the result of learning by doing and discovery of improved factory layout once the straightjacket of mechanical internal distribution of power was removed and the new plants constructed (see Devine, 1983; David and Wright, 2003; Field, 2005a).

And for the economy as a whole, large scale investment in government structures such as streets and highways can stimulate TFP growth in using sectors, as was likely true during the Depression years (Field, 2005a, 2006b), and as Aschauer (1989) has argued for the postwar period. It is interesting to contrast the effects of the boom in street and highway and other infrastructure construction during the 1930s with the rather different government financed capital formation boom that took place during the 1940s. The latter effort poured more than $10 billion of taxpayer money into GOPO

(Government Owned Privately Operated) plants. Almost all of this infusion was in manufacturing, and a large part of it went for equipment, particularly machine tools, in such strategic sectors as aluminum, synthetic rubber, aircraft engines, and aviation fuel refining (Gordon, 1969).[15] The immediate consequence was that TFP growth in manufacturing went negative, retarding TFP advance for the private nonfarm economy as a whole.[16]

To be fair to the equipment hypothesis, one might object that it implicitly requires that the machinery be allocated by private markets, rather than government central planners. Robert Higgs (1992) has argued that output growth in the war years was overstated,[17] and would probably attribute the poor TFP showing in manufacturing between 1941 and 1948 to the fact that it was *public* equipment investment rather than that it was public *equipment* investment. The beneficial impact of street and highway construction in the 1930s should, however, caution us against dismissing on a priori grounds the potential growth enhancing benefits of public infrastructure spending.

Conclusion

The generality of the equipment hypothesis, repeatedly reaffirmed by de Long and Summers, is therefore in doubt. Taking a broad overview of eight decades of twentieth century U.S. economic growth, there is absence of evidence of a systematic positive relationship between rates of equipment investment and TFP growth. The end of century surge in equipment investment, much of it IT related, did coincide with an accelerated

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[15] Most of this was then sold off to the private sector after the war, the main reason that 1941-48 shows the highest growth of the real net equipment stock.

[16] TFP growth in manufacturing declined from the 2.60 percent per year experienced between 1929 and 1941 to -.52 percent per year registered between 1941 and 1948 (see Field, 2005b).

[17] This overstatement, to the degree that it took place, should not, however, affect calculations over the 1941-48 interval.

growth in output per hour, above and beyond what one would have expected from the capital deepening alone. Taking a longer historical view, however, the IT productivity boom is less striking. The acceleration, though marked, produced a growth rate of the residual dwarfed by what took place during the Depression years, when there was a substantial increase in public infrastructure, but declines in the net stocks of private structures and equipment, or during the 1920s, when the ratio of structures to equipment was almost four times what it is today (see Figure 2).

To the degree that the mechanism identified in the equipment hypothesis is operative, its importance must vary across particular sectors and particular epochs or else be swamped by the effect of other influences. The problem for policy makers in favoring one type of investment over another is that it is quite difficult to determine ex ante, at any specific historical moment, which type (private structures, public infrastructure, private equipment) will have the biggest long term impact on TFP. The economic history of the United States in the twentieth century suggests that that there is nothing inherent in the category of equipment investment warranting a presumptive bias in its favor. To assume or conclude otherwise, and to base policy on this presumption, either in developing countries or in those aspiring to become so, entails the same risks as adopting industrial policies favoring particular sectors.

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