Demand adjusted capital input and potential output in the context of U.S. economic growth

Bitros, George C.

Athens University of Economics and Business, Department of Economics

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George C. Bitros
Professor of Political Economy, Emeritus
Athens University of Economics and Business
80 Patision Street, 6th Floor, Athens 104 34, Greece
Tel: +30 210 8203740 Fax: +30 210 8203301,
E-mail: bitros@aueb.gr

Abstract

Two alternative measures of demand adjusted capital input for the U.S. non-farm private business sector are derived and their differential impacts on the potential supply of output are compared to those obtained using the unadjusted index of capital input published by the Congressional Budget Office (CBO). The results show that, allowing for the demand pressure on the fixed assets of firms, leads to three effects. It raises the level of estimated potential output well above CBO's estimates; with the exception of the 1990s, the estimated growth rates turn out to be higher than those computed by CBO; and, lastly, the long term trend of the growth rates with and without the demand adjustment to the capital input is sloping downwards. The latter finding was not unexpected since aggregate demand, as reflected in the utilization rate of fixed assets by firms, has been trending downwards throughout the postwar period. Drawing on these findings it is concluded that the path to secular stagnation that the U.S. economy is following in the postwar period is not due solely to headwinds on the supply side. To some degree, perhaps significant, the deceleration in the expansion of productive capacity as well as in the intensity of its utilization is due to the declining long term aggregate demand.

JEL Classification: E01, E22, O47
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1. Introduction

The term *output*, with or without further qualification, is used to connote different things. For an example, consider the expression *potential output*. A cursory search in the relevant literature reveals that some use it to imply the highest level of Gross Domestic Product (GDP) that can be produced with a given mix of available resources and institutions; some others to signify the highest level of GDP that can be sustained over the long term; and still some others to denote the GDP that can be produced by an economy if all its resources are fully employed. This paper employs the following three definitions. The first of them is employed by the Congressional Budget Office (2001,

> *Potential output*—the trend growth in the productive capacity of the economy—is an estimate of the level of real GDP attainable when the economy is operating at a high rate of resource use. It is not a technical ceiling on output that cannot be exceeded. Rather, it is a measure of maximum sustainable output—the level of real GDP in a given year that is consistent with a stable rate of inflation.
>
> *Output supply* is the value of goods and services produced within a certain period, say a quarter or a year. It corresponds to the real GDP reported in the National Income and Product Accounts (NIPA). If output supply rises above potential output, constraints on productive capacity begin to bind, inflationary pressures build, and firms react by raising the utilization of their fixed assets. On the contrary, if output supply falls below potential output, resources are lying idle, inflationary pressures abate, and firms react by reducing the utilization of their fixed assets.
>
> *Output demand* is the value of goods and services sold by firms for purposes of consumption and investment. It corresponds to real GDP plus the change in the inventories of raw materials and intermediate and finished goods. If output demand exceeds (falls short of) output supply, inventories decline (expand), price pressures build (abate), and for some time output supply increases (declines) mainly through adjustments by firms in the utilization of their fixed assets. However, over the longer run, and depending on whether the changes in output demand are perceived as permanent or transitory, firms may expand (shrink) productive capacity, and hence potential supply of output, by accelerating investment in or retirement of fixed assets, respectively.

1) to estimate past and future growth rates of "maximum sustainable GDP consistent with a stable rate of inflation". In particular, as they explain in pages 8-9 of this publication, the approach by which they pursue this task is based on the Cobb-Douglas production function:

$$Q_t = A_t L_t^{1-\alpha} K_{t-1}^{\alpha}, \tag{1}$$

where the symbols are defined as follows: Q_t = real GDP in year *t*; L_t = billion hours worked in year *t*; K_{t-1} = real value of the capital stock in year *t*-1; A_t = Total Factor Productivity (TFP) in year *t;* and the parameter α stands for the income share of capital in the value of output.

Transforming (1) into logarithmic form, differentiating totally the resulting expression, and setting $\alpha = 0.3$ on account of the evidence that the payments to owners of capital have averaged roughly 30 percent of total U.S. income since 1947, yields:

$$\%\Delta Q_t = \%\Delta A_t + 0.7 \cdot \%\Delta L_t + 0.3 \cdot \%\Delta K_{t-1}\,. \tag{2}$$

This equation states that the growth rate of GDP equals the growth rate of TFP plus the weighted average of the growth rates of labor and capital; Or, to express it in a way indicating that TFP is computed as a residual, the growth rate of A_t is equal to the growth rate of Q_t not accounted for by the weighted average of the growth rates of L_t and K_t.

Equation (2) holds generally. That is, it holds for any period, any value of α, and any disaggregation, definition and measurement of the variables involved. Thus, by redefining it as:

$$\%\Delta Q_t^p = \%\Delta A_t^p + 0.7 \cdot \%\Delta L_t^p + 0.3 \cdot \%\Delta K_{t-1}^p\,, \tag{3}$$

where the upper index *p* denotes the "potential" values of the variables, the researchers of the Congressional Budget Office (henceforth CBO) proceed in two steps. In the first step, using (2) in conjunction with data from the U.S. Bureau of Economic Analysis (BEA), for the variables Q_t and K_t, and the Bureau of Labor Statistics (BLS), for the variable L_t, they compute the growth rates of A_t going back to 1949. Past values vary due to both regular and irregular factors. Therefore, to obtain the growth rates $\%\Delta L_t^p$ and $\%\Delta A_t^p$, the variables L_t and A_t are purged from their cyclical components by taking their centered five year moving average. As for the growth rate $\%\Delta K_t^p$, they obtain it by setting $K_{t-1} = K_{t-1}^p$ on account of the rationalization that:

> "…, the capital input does not need to be cyclically adjusted to create a "potential" level—the unadjusted capital input already represents its potential contribution to output. Although use of the capital stock varies greatly during the business cycle, the potential flow of capital services will always be related to the total size of the capital stock, not to the amount currently being used."

Lastly, upon inserting $\%\Delta A_t^p$, $\%\Delta L_t^p$ and $\%\Delta K_{t-1}^p$ into (3), they obtain the trend growth rate $\%\Delta Q_t^p$ as a weighted sum of the trend growth rates of labor and capital services plus the trend growth rate in TFP.

Table A1 in the Appendix[1] presents the time series of real GDP as a measure of output (Q_t), the labor (L_t) and capital (K_{t-1}) inputs, and labor productivity (Q_t / L_t). These constitute the series reported in the sources mentioned at the bottom of the table. Table A2 reports the most recent estimates and projections by CBO of potential output (Q_t^p) and its determinants. In the latter table the rows 1949-2016 refer to the historical estimates, whereas the rows 2017-2027 exhibit those that are projected. Finally, in line with the preceding remark, according to which they set $K_{t-1} = K_{t-1}^p$, the series of capital input reported by CBO is the same in both tables.

In Bitros (2019a) the above analytical framework was adapted and applied in conjunction with data for the U.S. nonfarm private business sector to investigate the linkages between capital input and potential output over the period 1949-2016. More specifically, by focusing on the changes in the composition of the capital stock in terms of structures, equipment and intangibles, average service lives, and relative prices of producer's to consumer's goods, that paper allowed for their influence on the capital input and traced the latter's effects on potential output. From the results it emerged that when the capital input is revised to reflect all these changes in the capital stock, the potential supply of output decelerates even faster than suggested by CBO's estimates and as a result the real economy in the years following the 2007 financial crisis appears to have adjusted to its lower potential faster than the protagonists of the secular stagnation hypothesis have suggested. But in as much as the deceleration of potential output is an undesirable development, it may not be due exclusively to the supply side headwinds discussed in that paper, since it may have trended downwards due also to slowing aggregate demand.

Thus, the focus in the present paper is to highlight the possible linkages of potential output supply to influences that may emanate from the demand side of the economy. To this effect, Section 2 lays out the model which is employed in the empirical part. This task is accomplished by expanding along the lines pursued in Bitros (2019a). In particular, the adjustments in the capital input adopted there are taken a step further to allow for the changes in the intensity of the utilization of fixed as-

[1] Numbers of tables in the Appendix are preceded by letter A.

sets, drawing on the conceptualization that they associate closely with the changes in aggregate output demand. Section 3 comments on the proxy variable used to capture the effects of changes in aggregate demand that are channeled to the potential supply of output through the capital input. Given that the main body of the data used in the calculations coincides with those presented in the aforementioned study, the emphasis in this section is placed mainly on the issues regarding the definition, measurement and data sources of the utilization rate. Section 4 reports on the results and their possible significance and policy implications; and lastly, Section 5 closes with a summary of the main findings and conclusions.

2. Linking potential supply and demand for output

Let us go back to equation (2) and redefine it so as to explain the percentage growth rate of output supply in the light of the adjustments made to the capital input in Bitros (2019a):

$$\%\Delta Q_t = \%\Delta A_t + 0.7 \cdot \%\Delta L_t + 0.3 \cdot \%\Delta \hat{K}_{t-1}. \tag{4}$$

From the definition it follows that the left side of (4) stands for the percentage growth rate of real GDP produced and supplied in any given period. As for the right side, this shows the contributions from three sources. Namely, the labor input, which corresponds to the percentage rate of change in the hours worked by workers, times 0.7; TFP, which is reckoned as a residual; and the percentage rate of change in the supply of the capital input times 0.3. The new element is the capital input, labeled $\hat{K}_{t-1}$, which signifies that the capital stock has been adjusted for changes in: (a) its composition in terms of structures, equipment and intangibles, (b) the average service lives of these producer's goods, and (c) their prices relative to consumer's goods.

In view of its treatment by CBO, the quantity of capital services used may or may not coincide with their available supply. The term $\%\Delta \hat{K}_{t-1}$ in (4) stands for the percentage rate of change in the maximum available supply of the capital input. It is an upper limit that cannot be exceeded. But how much of it is utilized in the production process period in-period out depends on the demand for output. Therefore, to obtain an approximate measure of the capital input used by firms, a convenient approach is to introduce the utilization rate (u_t) of fixed assets, which measures the percentage of available productive capacity utilized at time *t*. More specifically, we propose to set $\bar{\bar{K}}_{t-1} = u_{t-1}\hat{K}_{t-1}$, where $\bar{\bar{K}}_{t-1}$ denotes the amount of capital services used for the production of the aggregate output demanded. Thus, on account of this conceptualization, we may redefine (4) as in (5) below:

$$\%\Delta Q_t = \%\Delta \bar{\bar{A}}_t + 0.7 \cdot \%\Delta L_t + 0.3 \cdot \%\Delta \bar{\bar{K}}_{t-1}. \tag{5}$$

Observe that in this specification we have changed the symbol A_t to $\bar{\bar{A}}_t$. We have done so to indicate that the percentage rate of change of TFP corresponds to the revised definition and measurement of capital services. Finally, expressing (5) in terms of the potential values of the variables yields:

$$\%\Delta Q_t^p = \%\Delta \bar{\bar{A}}_t^p + 0.7 \cdot \%\Delta L_t^p + 0.3 \cdot \%\Delta \bar{\bar{K}}_{t-1}^p. \tag{6}$$

Now the differences between (3) and (6) are quite fundamental both from a theoretical and an empirical standpoint. Adopting the view that the available quantity of capital services represents their potential contribution to output, in essence CBO’s researchers maintain that the rate of potential economic growth is unrelated to capacity utilization. More specifically, even though they do not state it explicitly, they reason that while in the short run capacity utilization may affect the rate of economic growth due to price and other rigidities, in the long run the adjustments that take place in the economy render its influence irrelevant. Yet, numerous macroeconomic theorists have argued that the intensity with which firms use their fixed assets is too important to be ignored in the study of economic growth on at least three grounds. The first, emanating from a lengthy literature that includes contributions for example by Calvo (1975), Hulten (1986), Wen (1998) and Chatterjee (2005), establishes that capacity utilization relates positively to economic growth through the productivity channel. To see this linkage, assume that because of conditions that are inherent in production technologies, up to a point increases in capacity utilization raise productivity, whereas further increases thereafter lead to production bottlenecks and productivity declines. Under these circumstances the marginal cost of capacity utilization in terms of productive efficiency would not be zero and firms might have good economic reasons to use their fixed assets at less than full capacity even in the long run. But then applying (3) would result in overestimation of the rate of potential economic growth because implicit in this equation is the assumption that the marginal cost of capacity utilization is zero, which implies that firms operate their installations always at full capacity.

Unlike the productivity channel, which works through the supply side, the second ground for taking into account the linkage between capacity utilization and economic growth stems from a strand of literature that places sole emphasis on the demand side of the economy. Keynes (1936) was the first to point towards this direction. But his interest was in the study of the short run implications of aggregate demand and it was left to Harrod (1939), Khan (1959), Robinson (1962) and Kalecki (1971) to develop insightful dynamic models of the long run. Central to them all, as well as to the models presented more recently by researchers working in the their tradition, like for example Dutt (2006), Dutt, Ross (2007) and Shaikh (2009), is the role of capacity utilization as a channel of the influences from changes in aggregate demand to economic growth. Just to sketch the mechanism they envision to be at work, assume that we observe a very simple *Keynes-Kalecki* economy with the following characteristics:

- Each unit of capital stock K_t is operated by one unit of labor L_t ;
- The capital stock is operated with intensity u, and hence the quantity of output produced Y_t is equal to uK_t;
- The total output is distributed in the form of wages wL_t and profits rK_t, where w and r stand for the wage rate and the profit rate, respectively;[2]
- While workers consume all of their income, profit earners save some proportion s;
- Profit earners invest their savings so that $S_t = srK_t$ is always equal to investment I_t.

Now in this economy let the central bank reduce the discount rate to stimulate economic activity and combat unemployment. How might this policy influence economic growth and what might be the role in this regard of the utilization rate u ?

The reduction in the discount rate would certainly encourage some firms to bring forward their investment plans. As a result, investment would be expected to accelerate. Assume that the new higher level of planned investment is I_t^* and that the new higher level of the capital stock consistent with this investment is K_t^*. In turn, with u given, the planned supply of output will rise to a new higher level, say Y_t^*, and the same will happen to profits. Over time the share of profits will increase enough so that the savings by profit earners will come to rest at the higher planned level

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[2] It should be noted that the term “profits” corresponds to “income” from capital. In the long run and under competitive conditions the latter is the product of the normal return on capital r times the quantity of capital stock K_t.

of investment where we will have $S_t^* = I_t^*$. From this analysis it follows that the reduction in the central bank discount rate motivates stimulation of aggregate demand by raising the level of planned investment and boosting economic growth. By how much it depends on the utilization rate u, which in this case is held constant. However, having demonstrated the mechanism through which it works, it should not come as a surprise that according to this key model "demand creates its own supply", i.e. the opposite of Say's Law on which CBO's approach is based.

Could thinking along these lines offer some clues to the situation that emerged in the U.S. after the 2009 financial crisis? For this particular period CBO revised downwards its estimates of potential output by 5% due largely to reduced labor and capital inputs. But the Federal Reserve authorities could not do much because the policy interest rate had been reduced already closed to zero, so investment could not be stimulated through this channel. As a result many wandered: Could the reduction in the capital and labor inputs be due to the lack of demand and not of supply? Some world renowned economists thought that this might be the case and suggested policy initiatives to stimulate aggregate demand. For an example, consider Summers (2014a). Having returned to this question again and again since Summers (2013), in page 71 of this paper he answers by stating:

> We are seeing very powerfully a kind of inverse Say's Law. Say's Law was the proposition that supply creates its own demand. Here, we are observing that lack of demand creates its own lack of supply.

and in page 72 he goes on to recommend, among several other policies, that:

> The preferable strategy, I would argue, is to raise the level of demand at any given rate of interest—raising the level of output consistent with an increased level of equilibrium rates and mitigating the various risks associated with low interest rates that I have described.

Yet, perhaps because at the time the U.S. Economy was on its way back to meaningful rates of economic growth, shortly thereafter Summers (2014b) moved away from his emphasis on the lack of aggregate demand and in the direction of researchers who stress the lack of supply by expanding on Gordon's (2014) headwinds that forestall it.

In the meantime, even though the acrimonies between supply-siders and demand-siders appeared to have subsided, that debate was not in vain because it revealed in a forceful way the need for a unified analytical framework in which aggregate supply and demand for output would be given proper weight. The relevant literature is not void in this quest; Slowly and rather quietly research in this direction has made considerable progress. Although these efforts started somewhat earlier than the breakout of the financial crisis in 2009, three notable contributions since then are the ones by Dutt (2010), Ferri et al (2011) and Fazzari et al. (2013). If one has to single out only one common element in the models they present, this is none other than capacity utilization. That is why they provide even stronger support than the two grounds we invoked above to justify the introduction into (3) aggregate demand considerations through this channel.

To conclude this summary into the theoretical and empirical reasons that warrant the application of (3) in the form of (6), we find it least creative to take sides as to whether in any period and under any circumstances Say's Law holds sway directly or inversely. In our view in market economies with private ownership of the means of production economic growth is spearheaded other times by supply and other times by demand. So adopting a framework of analysis in which both are allowed to drive the course of potential output is prudent and may prove highly rewarding in terms of explanatory power.

3. Capacity utilization and potential capital input

Regarding the utilization of productive capacity in the U.S, the database maintained by the Federal Reserve Bank of St' Louis provides time series at various sectoral levels. The one most relevant to this research is the index labelled "total capacity utilization". But this index goes back only to 1966 and, in as much as we searched for alternative sources of information that might enable us to extend it backwards to match the CBO historical statistics, i.e. to 1949, it proved impossible. For this reason, we adopted the following procedure. The same database reports an index labelled "manufacturing capacity utilization" which goes back to 1947. Thus, assuming that total economic activity correlates strongly with the activity in the manufacturing sector, we regressed the index of total economy capacity utilization (tcu_t) on the index of manufacturing capacity utilization (mcu_t) and obtained the following equation:[3]

$$\begin{gathered} tcu_t = 12.295 + 0.862 mcu_t \\ (9.73) \quad (53.9) \\ \bar{R}^2 = 0.981,\ F(1{,}49)=2903.9,\ P(F)=0.0000 \end{gathered} \tag{7}$$

[3] In this equation the figures underneath the parameter estimates stand for the *t-statistic*, $\bar{R}^2$ is the adjusted coefficient of determination, and the standard criteria F and P ascertain the statistical significance of the equation.

With its help we then extended the index tcu_t back to 1949. These series are displayed in Figure 1. Observe that over the period 1966-2016 the index mcu_t tracks tcu_t exceedingly well. By implication, the strong fit of equation (7) ascertains that using it to project the series of total economy capacity utilization back to 1949 should not involve significant errors of measurement. How successfully this procedure performs is corroborated by the tight tracking of the solid line by the dotted extension of the dashed line.

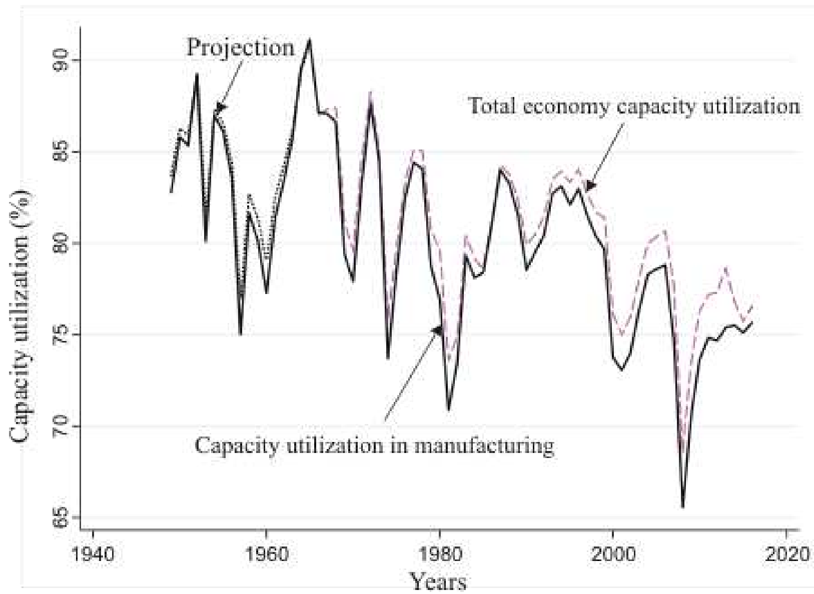

Figure 1: Reported and abridged indices of capacity utilization

Looking closer at this figure several significant observations come to mind. One, and perhaps most striking, is that with the exception of 1952 and 1965, which were war years for the U.S., the capacity utilization since 1949 never exceeded 87%. Actually, excluding the years of the Korean and Vietnam wars, the capacity utilization over the period 1949-2016 averaged 81.4%, whereas if we split the years into before and after 1980, the average declined from 83.4% in the first period to 79.0% in the second. From this evidence it follows that as a rule, when firms build productive facilities they never plan to use them fully. For technical, but also for reasons that are inherent to their economic calculus, firms build installations with the intention to use them at some "normal" intensity, leaving some slack capacity as buffer to adjust promptly to unexpected contingencies that develop because of shifts in demand, and not only. However, there is no way of knowing what this "normal" capacity utilization may be and hence, in order to measure the demand pressure on the fixed assets of firms, a possible way out is to assume that the "normal" is indicated by the two lowest historical values in the abridged series of capital utilization, draw a straight line through them, construct an index of relative demand pressure by drawing on the deviations of total capacity utilization from the calculated straight line, and lastly, use this index of demand pressure to compute a demand adjusted series of the capital input.

A second observation is that the time trend of capacity utilization is negative. Why is this so? From Bitros (2019a) we know that the composition of the capital stock has been changing all these decades in favor of equipment and intangibles and against infrastructures. Could this shift have anything to do with the long term decline in the capacity utilization? Infrastructural investments are generally more discrete and experience higher degrees of duplication than machinery and software. So the decline in their share in the capital stock would be expected to increase, not reduce capacity utilization. And the same is true with the advancement in automation which tends to favor relatively more the equipment part of the capital stock rather than that of infrastructure. Hence, even though we could not find hard evidence in this regard, most a priori considerations indicate that the culprit in the long term decline of capacity utilization may be associated with the decline in aggregate demand. Moreover, given that during the same period productive capacity as indexed by the ratio of net investment to the capital stock trended downwards at least in manufacturing,[4] the likelihood that both productive capacity and its utilization trended downwards mainly because of slackening aggregate demand does not seem baseless. But then capacity utilization influences potential capital input systematically and hence it should be treated as such by placing emphasis on the demand adjusted series of potential capital input.

Lastly, notice that capacity utilization traces two cycles. One that moves upwards from the middle of the 1950s and ends in a trough around 1980 and another that turns again upwards around the 1980s, reaches an apex in the middle of the 1990s, and since then it has been declining. These cycles are very lengthy and don't have much in common with the forces that drive the normal business cycles in the U.S. economy. Rather they are associated with protracted swings in production technologies and shifting consumer tastes, income distribution and economic policies. By implication, failing to account for the effects of relative demand pressure, channeled to potential capital input through capacity utilization, may introduce systematic biases into the estimates of potential output. To highlight this possibility, we carried out two separate calculations of the de-

[4] See Figure 17-6 in Gordon (2015, 399).

mand adjusted potential capital input: One based on CBO's capital input index K_{t-1} and another based of the capital input $\hat{K}_{t-1}$ derived in Bitros (2019a). Both these series are shown in Columns (1) and (2) of Table A4. In turn, the series K_{t-1} and $\hat{K}_{t-1}$ were multiplied by the index of relative demand pressure rdp_t shown in Column (3), and their five year centered moving average series are reported under the symbols $\bar{K}_{t-1}$ and $\bar{\bar{K}}_{t-1}$ in Columns (4) and (5), respectively.

Figure 2 displays the graphs of the series $K_{t-1} = K^P_{t-1}, \bar{K}^p_{t-1}$ and $\bar{\bar{K}}^p_{t-1}$. Observe that the graph of $\bar{K}^p_{t-1}$ lies above that of K^p_{t-1} throughout the period under consideration, whereas the graph of $\bar{\bar{K}}^p_{t-1}$ crosses the latter from below beginning in the 1990s. Therefore, by ignoring the influences of aggregate demand that are channeled to aggregate supply through the utilization rate, the deceleration

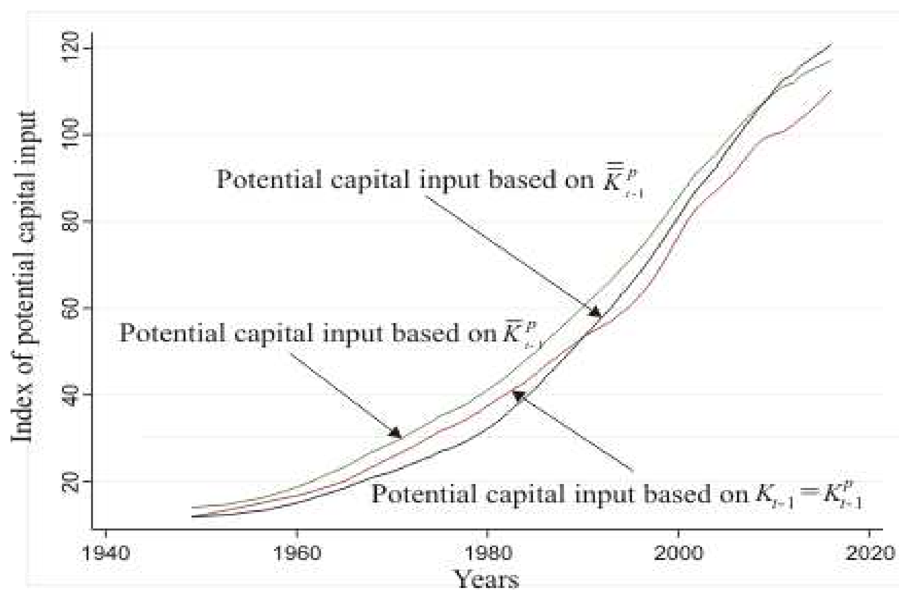

Figure 2: Indices of demand adjusted potential capital input

in recent years of potential output, and hence of economic growth, may have been less ominous than perceived by supply-siders. The objective of the presentation in the next section is to shed some light on this particular issue.

4. Potential output under alternative demand adjusted measures of capital input

The series of actual and potential output reported by CBO are shown in Columns (1) of Tables A1 and A2, respectively. For convenience we transferred both of them in Columns (1) and (2) of

Table A5. As indicated earlier, CBO researchers have computed the series of potential output using in equation (3) the convention that $K_{t-1} = K^{p}_{t-1}$. However, above we argued in support of the indices $\bar{K}_{t-1}$ and $\bar{\bar{K}}_{t-1}$ to account for the influences of aggregate demand via the channel of the utilization rate. Therefore the remaining task is to compute equation (6) under the alternative demand adjusted measures of potential capital input and assess the differences. Notice that in (7a) below we have changed the symbol $\%\Delta Q^{p}_{t}$ to $\%\Delta\tilde{Q}^{p}_{t}$. We have done so for two reasons: First, to indicate that applying this equation to the data reported by CBO does not give exactly their figures for potential output; and secondly, to hold the method of computation the same across all three equations.

$$\begin{aligned}
&\%\Delta\tilde{Q}^{p}_{t} = \%\Delta A^{p}_{t} + 0.7\cdot\%\Delta L^{p}_{t} + 0.3\cdot\%\Delta K^{p}_{t-1} && \text{(a)}\\
&\%\Delta\bar{Q}^{p}_{t} = \%\Delta\bar{A}^{p}_{t} + 0.7\cdot\%\Delta L^{p}_{t} + 0.3\cdot\%\Delta\bar{K}^{p}_{t-1} && \text{(b)} \qquad (7)\\
&\%\Delta\bar{\bar{Q}}^{p}_{t} = \%\Delta\bar{\bar{A}}^{p}_{t} + 0.7\cdot\%\Delta L^{p}_{t} + 0.3\cdot\%\Delta\bar{\bar{K}}^{p}_{t-1} && \text{(c)}
\end{aligned}$$

Columns (3), (4) and (5) of Table A5 show the series of potential output computed by applying (7) to the data. The series for potential output under the labels $\bar{Q}^{p}_{t}$ and $\bar{\bar{Q}}^{p}_{t}$ are much closed together. So, for minimizing possible controversies that may arise in relation to the index of capital input $\hat{K}_{t-1}$ which derives from Bitros (2019a), we shall narrow this assessment to $\tilde{Q}^{p}_{t}$ and $\bar{Q}^{p}_{t}$. Figure 3 displays the graphs of

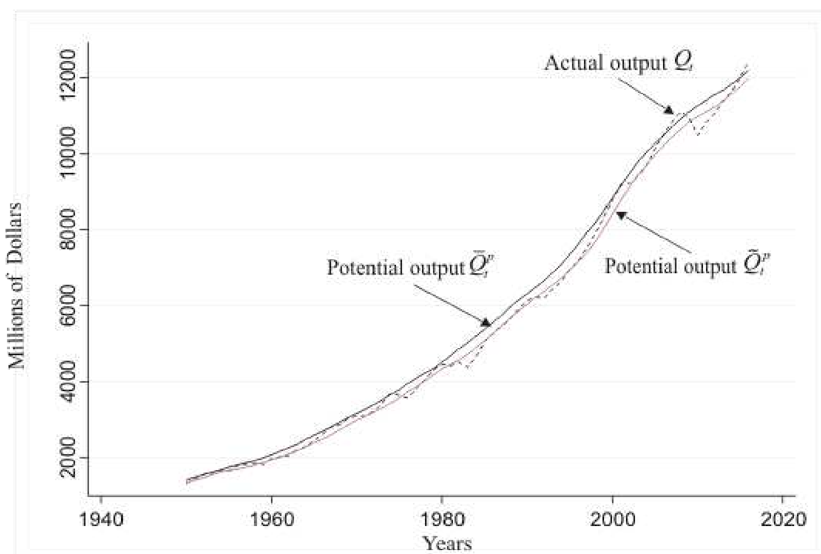

Figure 3: Actual and potential output under demand adjusted potential capital input $\tilde{K}^{p}_{t}$ and $\bar{K}^{p}_{t}$

these two series together with that of actual output Q_t. Observe that throughout the period under consideration the graph of the demand adjusted potential supply of output ($\bar{Q}_t^p$) lies above that computed in the absence of such adjustment ($\tilde{Q}_t^p$). What this finding implies is that above normal demand pressure on the fixed assets of firms shifts the potential supply of output upwards by leading to more intensive usage of the available capital stock as well as stirring up additional new investment. Or, stating the same inference in another way, gauging aggregate output supply in isolation from aggregate output demand results in an underestimation of potential output because in line with Summers's intuition the "lack of demand creates its own lack of supply".

However, aside from their differences in the levels, observe that the curves $\bar{Q}_t^p$ and $\tilde{Q}_t^p$ in Figure 3 differ also, albeit not widely, in their curvatures. The latter reflect the possible differences in the growth rates of the potential output from the two estimates. Thus, to highlight them we computed and in Figure 4 we present the 10 year average growth rates from the two series.

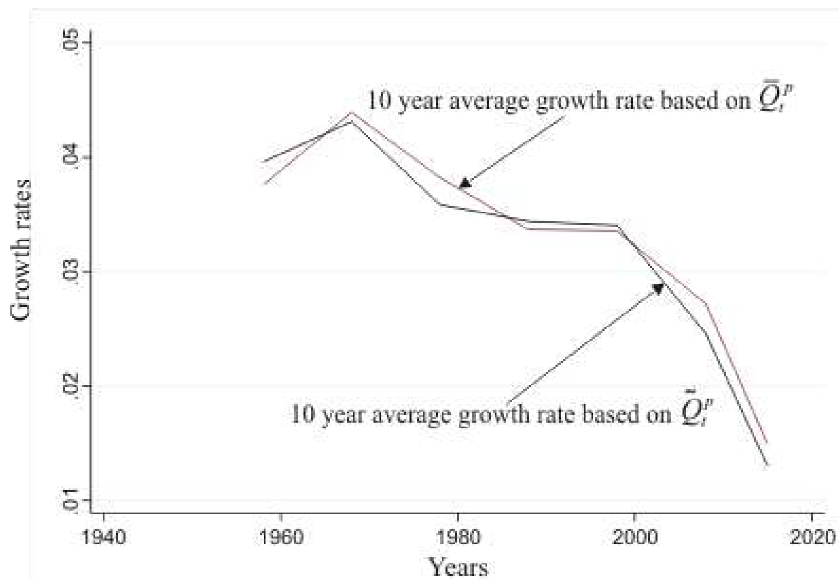

Figure 4: Ten year average growth rates, 1950-2016

From them it turns out that with the exception of the period in the 1990s, allowing for the demand pressure on the fixed assets of firms in the postwar period would have resulted in higher growth rates of the potential supply of output relative to those estimated by CBO. But otherwise one cannot fail to observe that by both estimates their downward long term trend remains intact. This transpires because, even though allowing for the impact of aggregate demand would lead to some improvement in the estimated growth rates of potential output, the aggregate demand has not been sufficiently robust to reverse their downward trend. Rather on the contrary, as documented by the long term decline in the utilization rate, aggregate demand has been trending downwards throughout these decades because of its own strong headwinds. By all indications then the U.S. economy has entered into a prolonged period of secular stagnation due to economic growth retardants that operate through both aggregate supply and aggregate demand. For this reason, in addition to the supply side headwinds, it is high time to identify and confront the forces that are reliable for the long term decline in aggregate demand.

5. Summary of findings and conclusion

CBO researchers estimate potential output by relying on the traditional Solow type growth accounting approach. When they reckon the flow of capital services, they postulate that the potential use of such services is equal to their available supply, because "the potential flow of capital services will always be related to the total size of the capital stock, not to the amount currently being used." However, be this as it may, there is considerable literature establishing that the potential flow of capital services is not related to the total size of the capital stock but to that which is useable on rational entrepreneurial grounds. The introduction in the estimations of potential output of demand-side considerations via the utilization rate is based on this conceptualization.

In particular, we derived two alternative measures of demand adjusted capital input for the U.S. nonfarm private business sector and compared their differential impacts on the potential supply of output relative to the unadjusted index of capital input published by CBO. The results from these comparisons showed that, allowing for the demand pressure on the fixed assets of firms, leads to three effects. It raises the levels of estimated potential output well above CBO's estimates; with the exception of the 1990s, the estimated growth rates turn out to be higher than those computed by CBO; and, lastly, the long term trend of the growth rates with and without the demand adjustment of the capital input is sloping downwards. The latter finding was not unexpected because aggregate demand as reflected in the utilization rate of fixed assets by firms has been trending downwards throughout the postwar period.

Drawing on these findings we conclude that the path to secular stagnation that the U.S. economy is following in the postwar period is not due solely to headwinds on the supply side. The deceleration in the expansion of productive capacity as well as in the intensity of its utilization cannot be explained in Isolation to the trends that prevail in the aggregate demand. So it is high time that research economists turn their attention to and confront the headwinds that beset this side of the puzzle.

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APPENDIX

Table A1: **Actual** data underlying CBO's computations of potential GDP in the U.S nonfarm private business sector

Year	$GDP = Q_t$ (1)	L_t (2)	K_{t-1} (3)	Labor productivity (4)=(1):(2)	Year	$GDP = Q_t$ (1)	L_t (2)	K_{t-1} (3)	Labor productivity (4)=(1):(2)
1949	1,309	83.4	11.8	15.7	1986	5,463	143.4	46.6	35.1
1950	1,441	80.1	12.1	16.2	1987	5,658	148.0	48.3	35.8
1951	1,548	82.7	12.6	16.8	1988	5,916	152.4	49.9	36.5
1952	1,595	86.6	13.0	17.4	1989	6,134	157.2	51.5	37.3
1953	1,675	87.5	13.5	17.9	1990	6,228	157.3	53.2	38.0
1954	1,650	89.7	13.9	18.2	1991	6,191	154.3	54.6	38.6
1955	1,790	86.7	14.3	18.5	1992	6,442	154.7	55.8	39.1
1956	1,823	90.1	14.8	18.8	1993	6,642	158.8	57.1	39.6
1957	1,860	92.4	15.3	19.3	1994	6,950	165.3	58.7	40.2
1958	1,823	91.8	15.8	19.8	1995	7,191	169.6	60.6	40.7
1959	1,975	88.0	16.2	20.3	1996	7,516	173.4	62.9	41.5
1960	2,010	92.0	16.7	20.8	1997	7,909	179.2	65.6	42.6
1961	2,053	92.6	17.2	21.4	1998	8,325	184.1	68.8	44.0
1962	2,194	91.6	17.9	22.0	1999	8,789	188.1	72.5	45.5
1963	2,295	93.6	18.5	22.6	2000	9,173	191.3	76.5	47.2
1964	2,448	94.6	19.2	23.2	2001	9,240	188.4	80.3	48.8
1965	2,624	98.7	20.0	23.9	2002	9,404	184.8	83.2	50.3
1966	2,812	103.0	21.1	24.8	2003	9,697	183.2	85.2	51.5
1967	2,865	103.7	22.3	25.7	2004	10,131	185.6	87.1	52.9
1968	3,018	106.0	23.4	26.5	2005	10,513	188.9	89.2	54.1
1969	3,110	109.3	24.5	27.3	2006	10,848	193.1	91.7	55.2
1970	3,105	107.9	25.6	28.0	2007	11,097	195.1	94.5	56.2
1971	3,222	107.3	26.7	28.5	2008	10,954	192.7	97.3	57.1
1972	3,438	111.3	27.7	28.9	2009	10,488	180.2	99.3	57.9
1973	3,687	115.9	29.0	29.4	2010	10,823	180.4	100.0	58.4
1974	3,631	116.2	30.4	29.9	2011	11,061	184.8	100.8	58.9
1975	3,571	111.4	31.6	30.4	2012	11,406	188.8	102.2	59.5
1976	3,826	115.6	32.4	30.8	2013	11,633	192.5	104.0	60.2
1977	4,044	120.0	33.3	31.2	2014	12,015	196.9	105.9	60.8
1978	4,312	126.0	34.5	31.7	2015	12,426	201.3	108.0	61.6
1979	4,455	130.3	35.9	32.2	2016	12,611	204.6	110.3	62.4
1980	4,415	129.5	37.4	32.3					
1981	4,517	130.9	38.9	32.3					
1982	4,373	128.1	40.3	32.7					
1983	4,657	130.3	41.6	33.2					
1984	5,047	138.1	42.9	33.7					
1985	5,262	142.0	44.8	34.4					

Notes
1. Actual GDP in billions of chained 2009 dollars.
2. Actual hours worked, billions of hours. Data from 1964 to 2016 from U. S. Bureau of Labor Statistics (BLS), Division of Major Sector Productivity, August 18, 2017. Data for 1949 to 1963, computed backwards using the percentages of annual change from BLS series PRS85006032.
3. Capital Services, index: 2009 = 100, lagged one year.

Source: CBO's June 2017 report: An Update to the Budget and Economic Outlook: 2017 to 2027, www.cbo.gov/publication/52801

Table A2: Historical and projected potential values of GDP and its determinants in the U.S nonfarm private business sector

Year	$GDP_t^P = Q_t^P$ (1)	L_t^P (2)	$K_{t-1} = K_{t-1}^P$ (3)	A_t^P (4)		Year	GDP_t^P (1)	L_t^P (2)	$K_{t-1} = K_{t-1}^P$ (3)	A_t^P (4)
1949	1,341	85.5	11.8	46.4		1989	6,142	164.7	51.5	85.9
1950	1,412	87.2	12.1	47.8		1990	6,332	166.5	53.2	86.9
1951	1,481	88.1	12.6	49.1		1991	6,508	168.4	54.6	87.8
1952	1,558	89.3	13.0	50.5		1992	6,680	170.7	55.8	88.7
1953	1,629	91.1	13.5	51.5		1993	6,869	173.4	57.1	89.5
1954	1,680	92.3	13.9	52.1		1994	7,080	176.3	58.7	90.4
1955	1,722	93.1	14.3	52.6		1995	7,313	179.6	60.6	91.3
1956	1,768	93.9	14.8	53.1		1996	7,564	182.4	62.9	92.3
1957	1,823	94.7	15.3	53.8		1997	7,871	184.9	65.6	93.9
1958	1,891	95.6	15.8	54.9		1998	8,242	187.4	68.8	95.8
1959	1,962	96.8	16.2	56.1		1999	8,639	189.7	72.5	97.9
1960	2,041	98.1	16.7	57.4		2000	9,035	191.3	76.5	100.0
1961	2,123	99.3	17.2	58.6		2001	9,415	192.8	80.3	102.0
1962	2,210	100.5	17.9	59.9		2002	9,737	193.8	83.2	103.9
1963	2,309	102.2	18.5	61.2		2003	10,015	194.3	85.2	105.9
1964	2,412	103.9	19.2	62.5		2004	10,290	194.7	87.1	107.9
1965	2,520	105.3	20.0	63.8		2005	10,569	195.2	89.2	109.8
1966	2,637	106.5	21.1	65.2		2006	10,809	195.7	91.7	111.1
1967	2,769	107.8	22.3	66.6		2007	11,016	196.0	94.5	111.9
1968	2,906	109.5	23.4	68.1		2008	11,226	196.5	97.3	112.7
1969	3,041	111.2	24.5	69.4		2009	11,405	197.1	99.3	113.5
1970	3,160	112.9	25.6	70.3		2010	11,525	197.4	100.0	114.3
1971	3,271	114.9	26.7	70.9		2011	11,657	197.9	100.8	115.1
1972	3,387	117.3	27.7	71.6		2012	11,829	198.8	102.2	115.9
1973	3,508	119.4	29.0	72.3		2013	12,033	200.0	104.0	116.7
1974	3,653	122.0	30.4	73.2		2014	12,257	201.4	105.9	117.5
1975	3,806	125.0	31.6	74.2		2015	12,492	202.9	108.0	118.3
1976	3,945	128.0	32.4	75.2		2016	12,719	203.9	110.3	119.2
1977	4,086	130.9	33.3	76.3		2017	12,943	204.6	112.6	120.1
1978	4,241	133.7	34.5	77.3		2018	13,191	205.4	115.0	121.1
1979	4,399	136.6	35.9	78.2		2019	13,459	206.2	117.7	122.3
1980	4,516	139.8	37.4	78.1		2020	13,740	207.0	120.4	123.5
1981	4,620	143.0	38.9	77.8		2021	14,033	207.8	123.0	124.9
1982	4,773	146.1	40.3	78.4		2022	14,339	208.6	125.6	126.3
1983	4,944	149.1	41.6	79.4		2023	14,655	209.5	128.3	127.8
1984	5,129	152.2	42.9	80.5		2024	14,977	210.4	130.9	129.3
1985	5,336	155.2	44.8	81.5		2025	15,306	211.3	133.7	130.9
1986	5,548	158.0	46.6	82.6		2026	15,642	212.2	136.5	132.4
1987	5,753	160.7	48.3	83.7		2027	15,986	213.0	139.4	134.0
1988	5,949	162.9	49.9	84.8						

Notes

1. Potential GDP in billions of chained 2009 dollars.
2. Potential hours worked in billions of hours.
3. Cyclically unadjusted capital Services, index: 2009 = 100, lagged one year. Hence, $K_{t-1} = K_{t-1}^P$.
4. Potential Total Factor Productivity, index: 2000 = 100

Source: CBO's June 2017 report: An Update to the Budget and Economic Outlook: 2017 to 2027, www.cbo.gov/publication/52801

Table A3: Indices of capacity utilization and relative demand pressure

Years	tcu_t (1)	mcu_t (2)	u_t (3)	rdp_t (4)		Years	tcu_t (1)	mcu_t (2)	u_t (3)	rdp_t (4)
1949		82.81	83.70	1.057		1986	81.16	80.97	81.16	1.099
1950		85.83	86.31	1.089		1987	84.30	84.03	84.30	1.140
1951		85.35	85.89	1.086		1988	83.77	83.30	83.77	1.135
1952		89.25	89.26	1.129		1989	82.48	81.64	82.48	1.121
1953		80.11	81.38	1.039		1990	79.90	78.55	79.90	1.092
1954		86.98	87.30	1.109		1991	80.49	79.53	80.49	1.101
1955		86.14	86.58	1.102		1992	81.44	80.41	81.44	1.114
1956		83.61	84.39	1.078		1993	83.48	82.73	83.48	1.142
1957		75.02	76.99	1.000		1994	83.93	83.13	83.93	1.151
1958		81.63	82.69	1.062		1995	83.33	82.11	83.33	1.145
1959		80.14	81.40	1.050		1996	84.04	82.99	84.04	1.156
1960		77.31	78.96	1.025		1997	82.71	81.50	82.71	1.141
1961		81.43	82.51	1.066		1998	81.70	80.43	81.70	1.130
1962		83.46	84.26	1.088		1999	81.41	79.67	81.41	1.129
1963		85.65	86.15	1.113		2000	76.12	73.76	76.12	1.067
1964		89.54	89.51	1.159		2001	74.99	73.06	74.99	1.056
1965		91.13	90.88	1.180		2002	75.98	73.98	75.98	1.069
1966	87.00	87.16	87.00	1.130		2003	78.10	76.40	78.10	1.096
1967	87.34	87.08	87.34	1.137		2004	79.99	78.31	79.99	1.121
1968	87.40	86.63	87.40	1.139		2005	80.38	78.60	80.38	1.128
1969	81.22	79.42	81.22	1.066		2006	80.67	78.82	80.67	1.134
1970	79.58	77.90	79.58	1.050		2007	77.72	74.67	77.72	1.099
1971	84.63	83.37	84.63	1.111		2008	68.52	65.54	68.52	1.000
1972	88.27	87.65	88.27	1.160		2009	73.57	70.72	73.57	1.055
1973	85.13	84.46	85.13	1.121		2010	76.28	73.66	76.28	1.088
1974	75.80	73.69	75.80	1.017		2011	77.18	74.85	77.18	1.101
1975	79.80	78.34	79.80	1.062		2012	77.32	74.68	77.32	1.105
1976	83.44	82.49	83.44	1.106		2013	78.64	75.40	78.64	1.123
1977	85.12	84.41	85.12	1.129		2014	76.83	75.53	76.83	1.103
1978	85.05	84.08	85.05	1.131		2015	75.75	75.11	75.75	1.092
1979	80.81	78.72	80.81	1.081		2016	76.52	75.67	76.52	1.103
1980	79.58	76.94	79.58	1.068						
1981	73.59	70.89	73.59	1.006						
1982	74.88	73.46	74.88	1.021						
1983	80.40	79.32	80.40	1.084						
1984	79.20	78.11	79.20	1.072						
1985	78.60	78.40	78.60	1.067						

Notes
1. Total capacity utilization in column (1) corresponds to the time series CAPUTLB50001SQ from the database of the Federal Reserve Bank of St' Louis.
2. Manufacturing capacity utilization in column (2) corresponds to the time series CAPUTLB00004SQ from the database of the Federal Reserve Bank of St' Louis.

Capacity utilization index obtained as explained in the text.

Table A4: Alternative estimates of the demand adjusted potential capital input in the U.S nonfarm private business sector[1]

Years	$K_{t-1} = K^p_{t-1}$ (1)	$\hat{K}_{t-1}$ (2)	rdp_t (3)	$\bar{K}^p_{t-1}$ (4)	$\bar{\bar{K}}^p_{t-1}$ (5)		Years	K_{t-1} (1)	$\hat{K}_{t-1}$ (2)	rdp_t (3)	$\bar{K}^p_{t-1}$ (4)	$\bar{\bar{K}}^p_{t-1}$ (5)
1949	11.8	10.2	1.057	13.9	11.7		1986	46.6	38.9	1.099	51.9.	43.7
1950	12.1	10.4	1.089	14.2	11.9		1987	48.3	40.9	1.140	54.0	46.0
1951	12.6	10.7	1.086	14.4	12.0		1988	49.9	42.7	1.135	56.0	48.3
1952	13.0	10.9	1.129	14.5	12.1		1989	51.5	44.5	1.121	58.2	50.7
1953	13.5	11.1	1.039	14.7	12.3		1990	53.2	46.6	1.092	60.3	53.1
1954	13.9	11.5	1.109	15.2	12.6		1991	54.6	48.5	1.101	62.5	55.6
1955	14.3	11.8	1.102	15.6	12.9		1992	55.8	49.9	1.114	64.4	57.9
1956	14.8	12.1	1.078	16.0	13.2		1993	57.1	51.5	1.142	66.6	60.3
1957	15.3	12.6	1.000	16.5	13.5		1994	58.7	53.3	1.151	69.0	63.0
1958	15.8	13.0	1.062	17.2	14.0		1995	60.6	55.5	1.145	71.3	65.6
1959	16.2	13.3	1.050	17.9	14.5		1996	62.9	58.1	1.156	73.8	68.3
1960	16.7	13.6	1.025	18.6	15.0		1997	65.6	61.0	1.141	76.5	71.3
1961	17.2	13.9	1.066	19.4	15.6		1998	68.8	64.3	1.130	79.3	74.4
1962	17.9	14.2	1.088	20.4	16.3		1999	72.5	68.0	1.129	82.3	77.6
1963	18.5	14.7	1.113	21.4	17.0		2000	76.5	72.2	1.067	85.4	81.0
1964	19.2	15.2	1.159	22.3	17.7		2001	80.3	76.5	1.056	88.5	84.3
1965	20.0	15.8	1.180	23.3	18.4		2002	83.2	79.7	1.069	91.4	87.6
1966	21.1	16.6	1.130	24.4	19.2		2003	85.2	81.7	1.096	93.4	89.9
1967	22.3	17.5	1.137	25.7	20.1		2004	87.1	83.6	1.121	95.7	92.8
1968	23.4	18.3	1.139	26.9	20.9		2005	89.2	86.0	1.128	98.4	95.9
1969	24.5	19.1	1.066	27.8	21.5		2006	91.7	89.1	1.134	101.0	99.0
1970	25.6	20.0	1.050	28.8	22.2		2007	94.5	92.6	1.099	103.4	101.9
1971	26.7	20.6	1.111	30.0	23.1		2008	97.3	96.4	1.000	105.8	104.9
1972	27.7	21.3	1.160	31.2	23.9		2009	99.3	99.5	1.055	107.7	107.5
1973	29.0	22.1	1.121	32.4	24.8		2010	100.0	100.0	1.088	109.4	110.1
1974	30.4	23.1	1.017	33.7	25.8		2011	100.8	101.4	1.101	111.2	112.7
1975	31.6	24.1	1.062	35.0	26.8		2012	102.2	103.5	1.105	112.0	114.0
1976	32.4	24.6	1.106	35.9	27.5		2013	104.0	106.2	1.123	113.8	116.2
1977	33.3	25.3	1.129	36.8	28.3		2014	105.9	109.0	1.103	115.1	117.8
1978	34.5	26.3	1.131	38.1	29.5		2015	108.0	112.3	1.092	116.2	119.2
1979	35.9	27.5	1.081	39.6	30.8		2016	110.3	115.6	1.103	117.2	120.8
1980	37.4	29.0	1.068	41.0	32.2							
1981	38.9	30.4	1.006	42.6	33.7							
1982	40.3	31.9	1.021	44.3	35.5							
1983	41.6	33.3	1.084	46.1	37.4							
1984	42.9	34.6	1.072	48.0	39.4							
1985	44.8	36.7	1.067	49.8	41.4							

Notes

1. Capital input in column (1) as reported by CBO (see Table A1 and A2 above)
2. Capital input in column (2) from Bitros (2017). Computed to allow for compositional and other changes in the capital stock in the U.S nonfarm private business sector.
3. Index of relative demand pressure on the fixed assets of firms derived as explained in the text.
4. Five year centered moving average of the capital input derived by multiplying columns (3) and (1).
5. Five year centered moving average of the capital input derived by multiplying columns (3) and (2)

<u>Table A5</u>: Potential output under alternative demand adjusted estimates of potential capital input in the U.S nonfarm private business sector

Years	Q_t (1)	Q_t^p (2)	$\tilde{Q}_t^p$ (3)	$\bar{Q}_{t-1}^p$ (4)	$\bar{\bar{Q}}_{t-1}^p$ (5)
1949	1,309	1,341	1,341	1,386	1,374
1950	1,441	1,412	1,410	1,447	1,436
1951	1,548	1,481	1,476	1,518	1,509
1952	1,595	1,558	1,547	1,581	1,574
1953	1,675	1,629	1,617	1,655	1,650
1954	1,650	1,680	1,665	1,719	1,714
1955	1,790	1,722	1,705	1,792	1,787
1956	1,823	1,768	1,750	1,848	1,843
1957	1,860	1,823	1,801	1,897	1,891
1958	1,823	1,891	1,868	1,970	1,965
1959	1,975	1,962	1,939	2,041	2,035
1960	2,010	2,041	2,020	2,139	2,133
1961	2,053	2,123	2,098	2,222	2,215
1962	2,194	2,210	2,188	2,325	2,318
1963	2,295	2,309	2,283	2,435	2,427
1964	2,448	2,412	2,384	2,561	2,552
1965	2,624	2,520	2,486	2,664	2,657
1966	2,812	2,637	2,601	2,776	2,768
1967	2,865	2,769	2,724	2,901	2,894
1968	3,018	2,906	2,855	3,022	3,013
1969	3,110	3,041	2,981	3,142	3,134
1970	3,105	3,160	3,092	3,259	3,251
1971	3,222	3,271	3,197	3,379	3,371
1972	3,438	3,387	3,311	3,506	3,498
1973	3,687	3,508	3,431	3,636	3,628
1974	3,631	3,653	3,576	3,779	3,773
1975	3,571	3,806	3,729	3,934	3,929
1976	3,826	3,945	3,870	4,075	4,073
1977	4,044	4,086	4,020	4,219	4,219
1978	4,312	4,241	4,177	4,355	4,359
1979	4,455	4,399	4,339	4,497	4,503
1980	4,415	4,516	4,459	4,662	4,670
1981	4,517	4,620	4,567	4,844	4,857
1982	4,373	4,773	4,721	5,027	5,045
1983	4,657	4,944	4,895	5,199	5,219
1984	5,047	5,129	5,080	5,377	5,400
1985	5,262	5,336	5,281	5,551	5,574
1986	5,463	5,548	5,482	5,746	5,771
1987	5,658	5,753	5,681	5,928	5,951
1988	5,916	5,949	5,866	6,131	6,154
1989	6,134	6,142	6,044	6,316	6,338
1990	6,228	6,332	6,221	6,485	6,505
1991	6,191	6,508	6,384	6,657	6,674
1992	6,442	6,680	6,553	6,838	6,855
1993	6,642	6,869	6,730	7,058	7,073
1994	6,950	7,080	6,933	7,300	7,314
1995	7,191	7,313	7,160	7,568	7,580
1996	7,516	7,564	7,398	7,845	7,856
1997	7,909	7,871	7,693	8,132	8,144
1998	8,325	8,242	8,034	8,421	8,431
1999	8,789	8,639	8,409	8,737	8,745
2000	9,173	9,035	8,778	9,053	9,060
2001	9,240	9,415	9,132	9,381	9,388
2002	9,404	9,737	9,435	9,684	9,691
2003	9,697	10,015	9,701	9,942	9,951
2004	10,131	10,290	9,963	10,206	10,218
2005	10,513	10,569	10,229	10,447	10,455
2006	10,848	10,809	10,454	10,673	10,681
2007	11,097	11,016	10,637	10,880	10,889
2008	10,954	11,226	10,826	11,090	11,101
2009	10,488	11,405	10,993	11,262	11,276
2010	10,823	11,525	11,105	11,413	11,429
2011	11,061	11,657	11,229	11,574	11,591
2012	11,406	11,829	11,390	11,708	11,711
2013	11,633	12,033	11,577	11,875	11,861
2014	12,015	12,257	11,776	12,020	11,989
2015	12,426	12,492	11,988	12,205	12,162
2016	12,611	12,719	12,197	12,345	12,286

<u>Notes</u>

1. Actual historical values of output reported by CBO (see Table A1)
2. Potential output reported by CBO (see Table A2)
3. Potential output computed from equation (7a)
4. Potential output computed from equation (7b)
5. Potential output computed from equation (7c)