How Severe is the "Great Recession"? : A Note on Assessing Business Cycles*

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1 Introduction

The overall economic condition of an economy is usually described by both its long-run growth rate and its level of output relative to its long-run trend. The former is the trend component while the short run fluctuations about a trend component is what is commonly referred to as the business cycle. This short note describes the difficulty of assesing the trend component and the depth of recessions particularly in dowturns like the current one.

The study and dating of business cycles in the U.S. and elsewhere has a very long tradition. The most renowned and ardent student of business cycles was Wesley Mitchell, one of the early leaders of the National Bureau of Economic Research. Mitchell devoted his career to the study of cycles and in one of his landmark books, *Measuring Business Cycles*, written with Arthur Burns in 1946, they describe the business cycle as follows:

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> Business cycles are a type of fluctuation found in aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occuring about the same time in many economic activities followed by similarly general recessions, contractions and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.

Given that perspective, the NBER researchers led by Mitchell, Burns, and susequent generations of researchers have treated business cycles as distinct economic phenomena, the identification of which is a tool for economic researchers interested in probing their causes and implications and thinking about policy responses. The knowledge that business cycles are recurrent phenomena representing fluctuations around a growth trend is a useful starting point for research. For example, an important test proposed for econometric models of the economy, quantitative real business models and Dynanmic Stchastic General Equilibrium (DSGE) models is that they should produce, when shocked, fluctuations that mimic the characteristics of business cycles.[1] But it is also true that from the very beginning there has been debate and uncertainty about how to date cycles and the characteristics of those cycles. For example there has been extended debate about the difference in characterisitics of pre-war business cycles and post-war business cycles.[2]

It is not surprising that business cycle dating is the subject of much discussion. The purpose of this note is to point out some issues in measuring the depth and duration of business cycles. In particular assessing those features requires taking a stand on the underlying trend rate of growth of the economy. This is central to determining whether one cycle is "worse" than another. The NBER Business Cycle dating committee is the body that claims the responsibility for dating business cycles and a majority of researchers rely on their judgement.[3] But there are alternatives to the NBER approach.

Modern business cycle theory has adopted new methods for decomposing economic time series into growth and cycle components. The method used in most early real business cycle research

[1] see eg, King and Plosser (1994)

[2] see for example Watson (1994).

[3] As do we. See http://econsnapshot.wordpress.com.

is the Hodrick-Prescott filter (HP). The HP filter attempts to separate low frquency movements in output from the "business cycle" frequencies.

The HP filter can be intepreted as a "low-pass" filter, meaning that it separates low frequency movements (trend compents) from the raw data leaving the cyclical components. Critics realized that it could be improved on with a band pass filter that could more precisely isolate the trend and cycle components, for example see Baxter and King (1999).

These mechanical methods for separating trend and cycle componenets and determining turning points have the advantage that they don't rely on judgement, only on the specification of the relative variances of the trend and cycle components and some other features of the filter. They have a disadvantage in that they are heavily influenced by endpoints in determining the trend component. This problem becomes very apparent in recessions like the current one because of its duration and severity but it would also be an issue in any recession. Some versions of the bnadpass filter do better than others at dealing with this problem.

2 Business Cycle Methods

2.1 The NBER

As we noted in the introduction the default source for defining the *turning points* of business cycles is the NBER Business Cycle Dating Committee. There was widespread misconception for many years that the methodology of the NBER Committee was to define a recession as two succesive quarters of negative change in real GDP and many textbooks reflected this view. The NBER is clear, however, that this is not the criteria. In their official statement they take great care to point this out:

> The NBER does not define a recession in terms of two consecutive quarters of decline in real GDP. Rather, a recession is a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales.

This is clear enough and the 2001 recession is proabably the best illustration of a business cycle that, while it did not exhibit two consecutive quarters of deline in real GDP, was characterized by a prolonged decline in employment. Nor does the committee have a fixed set of weights they apply to the indicators they do look at and they consider a broad variety of them. As they say:

> The Committee does not have a fixed definition of economic activity. It examines and compares the behavior of various measures of broad activity: real GDP measured on the product and income sides, economy-wide employment, and real income. The Committee also may consider indicators that do not cover the entire economy, such as retail sales and the Federal Reserve's index of industrial production (IP).

2.2 The Hodrick-Prescott Filter

Suppose one wanted a method of identifying business cycles that duplicated the essential interpretation of Wesley Mitchell and the early NBER researchers by identifying business cycles with fluctuations that occur with frequency lower than about eight years. One alternative would be to assume a stochastic trend and first difference the log of the series to remove the trend and represent the cycle as the remainder. This procedure however emphasizes really high frequency movements in the data which is inconsistent with the Burns and Mitchell notion that the cycle is a phenonmenon that occurs with a frequency of three to five years. So the more popular alternative is to assume we can represent a series, say the log of real GDP, as the sum of a cyclical compnent y_t^c and a growth component y_t^g. The filtering problem is then to choose a growth component that minimizes the the following loss function:

$$\sum_{t=1}^{T}(y_t^c)^2+\lambda\sum_{t=1}^{T}\left[\left(y_{t+1}^g-y_t^g\right)-\left(y_t^g-y_{t-1}^g\right)\right]^2. \tag{1}$$

This loss function trades off the extent to which the growth component tracks the original series against the smoothness of the trend. As $\lambda\to\infty$ the growth component approaches a linear trend. If one is working with quarterly data a choice of $\lambda=1600$ eliminates fluctuations lower than about eight years.

To get an idea what this filter does and how it compares to the NBER dating, Figure 1 shows the series and its estimated trend component. The corresponding business cycle is shown in Figure 2.

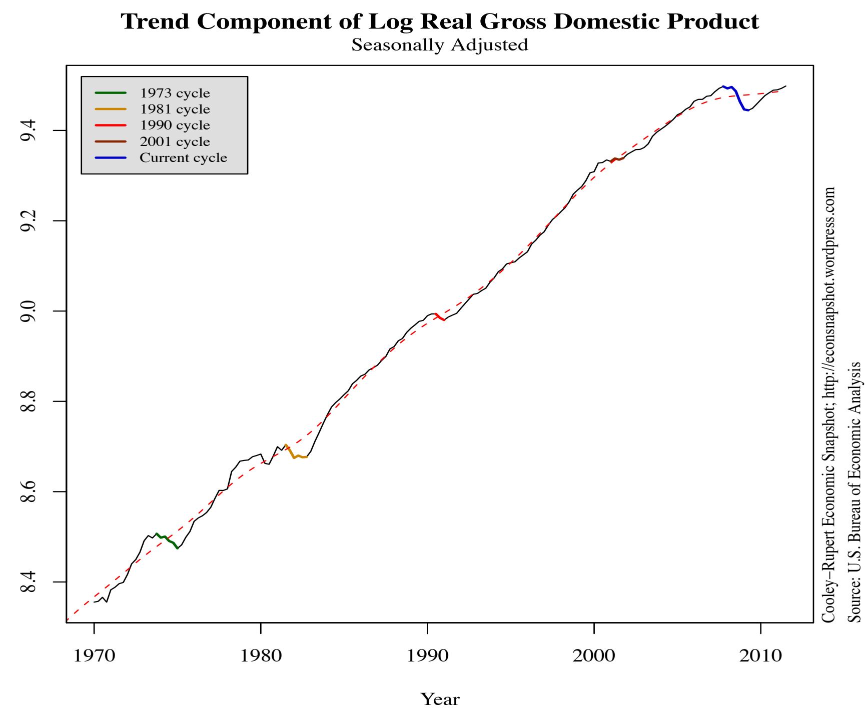

Figure 1: HP Trend Component of (log) Real GDP.

Immediately it becomes obvious when looking at Figure 2 that there must be an issue with the HP filter. Although the current cycle (according to the NBER the recession began in December, 2007) it identifies is in very close agreement with the NBER *dating* it doesn't look anywhere near as severe as has been described and does not appear as bad as the 1981 contraction. How can this be? The answer is obvious when one looks at Figure 1. The HP filter is very sensitive to movements in the series and adjusts its estimated trend component accordingly. The problem is that it implies that the trend component is now on the order of less than one percent growth per year. But growth rates like that have not been experienced over any long horizon and not since the 1930's. More importantly, when we look at the implied cycles relative to the implied trend the current recession does not look like the most severe on since the 1930's, all because the trend is reduced so severely. Clearly the HP filter is over-responsive in some sense. So what is the alternative?

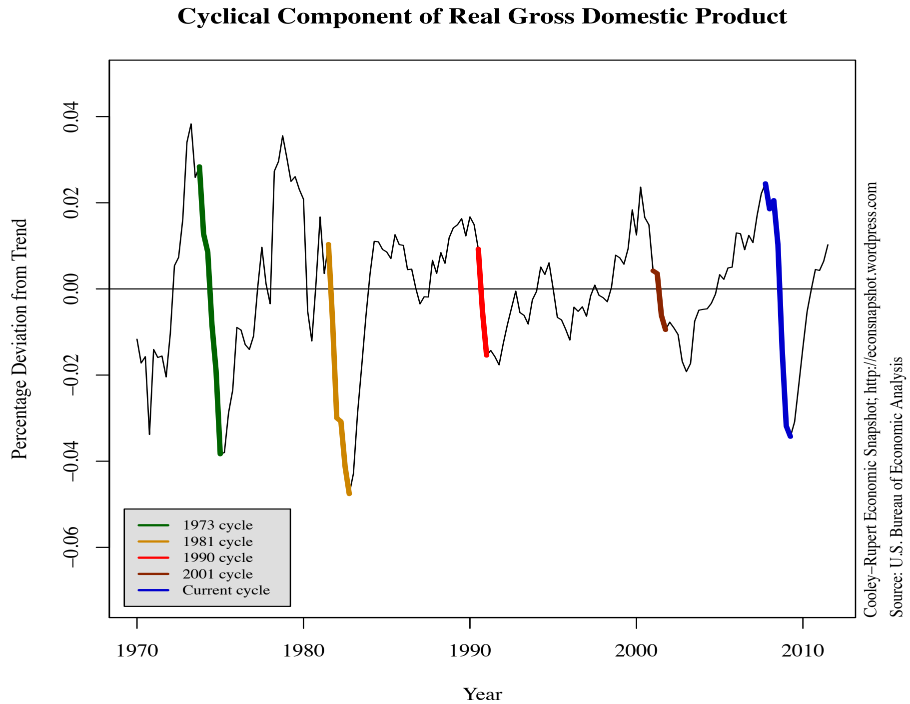

Figure 2: Cyclical Component of (log) Real GDP.

2.3 Bandpass Filters

Some authors have suggested using a bandpass filtering approach, designed to isolate specific frequency components in a time series. Since the Burns and Mitchell (1946) original definition of the business cycle is set in the frequency domain, a business cycle researcher would naturally want to only analyze movements within a certain band of frequencies (related to 1.5 to 8 years). The ideal bandpass filter achieves this result, but is infeasible because it requires an infinite amount of data. Baxter and King (1999) and Christiano and Fitzgerald (2003) develop approximations to the ideal bandpass filter that are optimal under different conditions.

The ideal bandpass filter is a direct result from the Spectral Representation Theorem which states that a broad range of time series, y_t, can be represented as an integral sum of orthogonal frequency components, $y_t = \int_{-\pi}^{\pi} \xi(\omega) d\omega$. If a researcher is concerned with only analyzing the time series within business cycle frequencies, y_t^c, then the corresponding decomposition is $y_t^c = \int_{-\pi}^{\pi} \beta(\omega)\xi(\omega) d\omega$, where $\beta(\omega) = 1$ for frequencies corresponding to the business cycle and zero elsewhere. This result can be stated as an infinite order moving average, $y_t^c = B(L)y_t$, where

$$B(L) = \sum_{j=-\infty}^{\infty} B_j L^j, \quad L^j y_t = y_{t-j} \tag{2}$$

defines the ideal bandpass filter and B_j are the corresponding ideal filter weights.

Baxter and King (1999) recommend using a truncation of the ideal bandpass filter with symmetric weights and fixed lead/lags for 12 quarters. This is the result of choosing a feasible symmetric filter, $a_K(L) = \sum_{j=-K}^{K} a_j L^j$, that minimizes a squared loss function, where K represents the maximum lead/lag length. Baxter and King (1999) solve the problem in the frequency domain represented as

$$\min_{\alpha_K(\omega)} \frac{1}{2\pi} \int_{-\pi}^{\pi} |\beta(\omega) - \alpha_K(\omega)|^2 d\omega \tag{3}$$

where $\alpha_K(\omega)$ is the frequency analog of $a_K(L)$, $\beta(\omega)$ is the ideal bandpass filter defined above, and again K represents the maximum lead/lag length. The resulting optimal symmetric filter is to set $a_j = Bj$ for $j = 0, 1, \ldots, K$ and zero elsewhere.

While this filter is a good approximation to the the ideal bandpass filter, its major downfall is having to drop 3 years of data at the beginning and end of the data series as required by imposing symmetry. Figure 3 and Figure 4 show the trend and cyclical components of log real GDP using the Baxter-King bandpass filter. The trend component is clearly less susceptible to large downturns in the series, however at the cost of dropping observations.

Christiano and Fitzgerald (2003) alternatively choose an approximation, $\hat{y}_t{}^c$, that minimizes the more flexible objective

$$\mathbb{E}\Big[(y_t^c - \hat{y}_t{}^c)^2 \mid y_1, \ldots, y_T\Big]. \tag{4}$$

The resulting optimal filter is asymmetric and uses varying leads and lags that utilize the entire data series. The filter can therefore yield current estimates of the business cycle compnent. Christiano and Fitzgerald (2003), (CF), show that these estimates are more accurate that those derived from the HP filter but are still noisy estimates of the true bandpass filtered series. We show the resulting trend component of log real GDP using the CF bandpass filter and its implied cyclical deviations

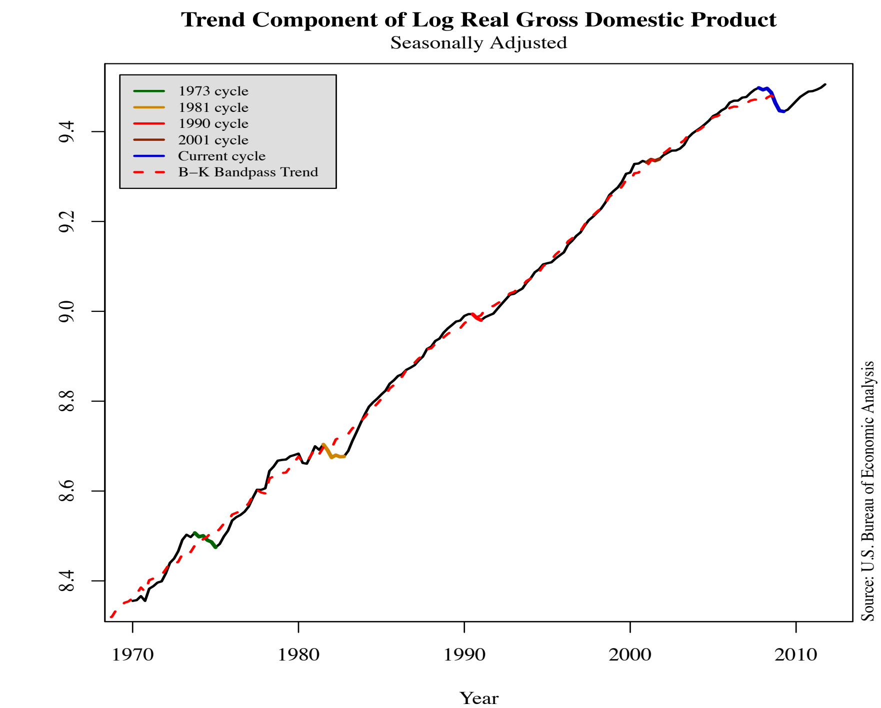

Figure 3: BK Bandpass Trend Component of (log) Real GDP.

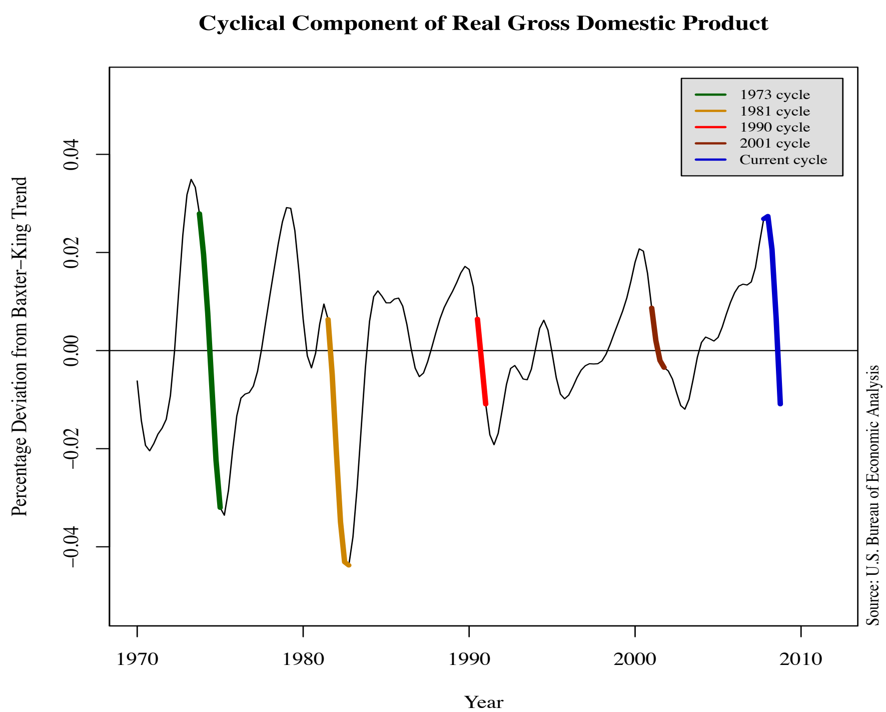

Figure 4: Cyclical Component of (log) Real GDP.

in Figure 5 and Figure 6.

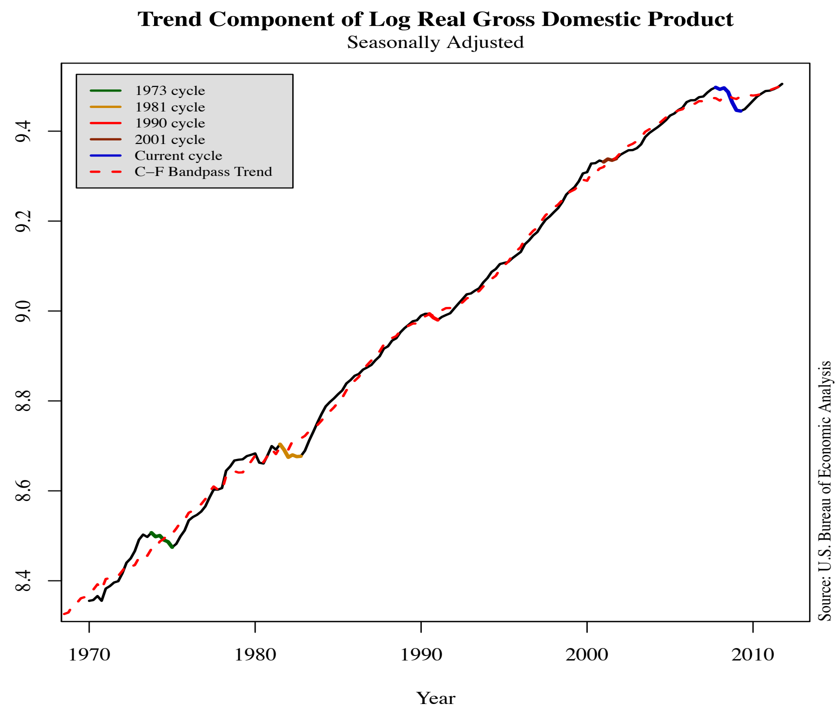

Figure 5: CF Bandpass Trend Component of (log) Real GDP.

The filter still has problems at the end of the data series and shows an estimated growth component that has average annual growth rates well below 1%.

3 Filter Experiments

Below we show a series of counterfactual experiments. These experiments are simple, but are designed to highlight the dangers of relying on trend estimates particularly at the end of a data series.

3.1 2007 Cycle

Above we show that the HP filter estimates the trend component in real GDP to be growing less than 1% annually, a long-term growth rate not seen in post-war output. The annual growth rate of

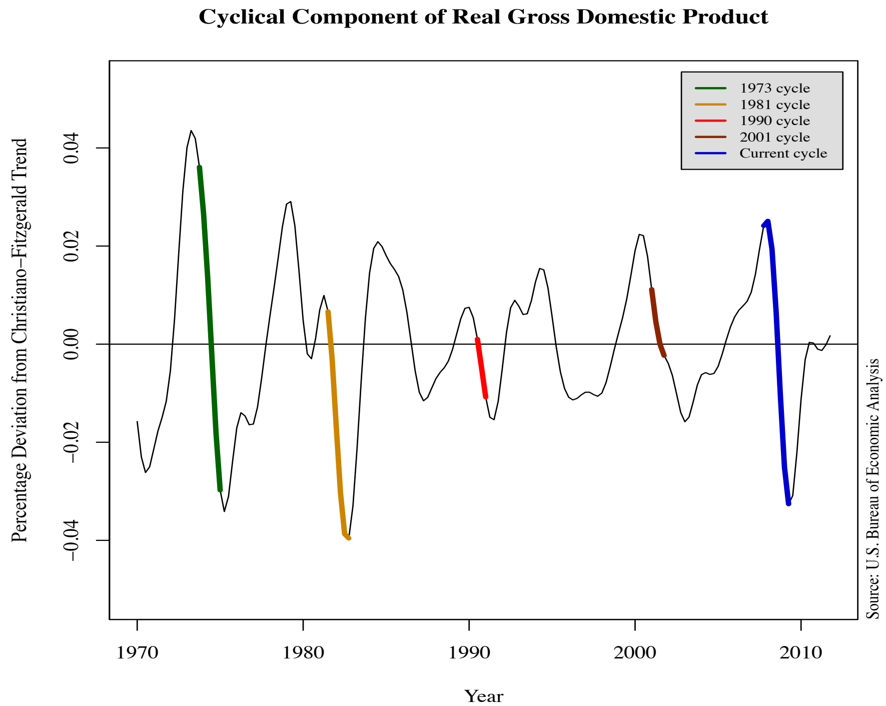

Figure 6: Cyclical Component of (log) Real GDP.

the HP trend never drops below 2% until 2005 Q3. Suppose, since the HP filter is sensitive to the ends of the data series, that the Great Recession is leading it to underestimate the trend. Figure 7 shows the implied trend component and cyclical deviations if you prevent the filter from dropping below say 2%. We cut off the HP trend at 2005 Q3 and extend it at 2% annualized growth. We then compare the resulting cyclical deviations.

Several things become apparent in Figure 7. First, assuming a long term growth path more consistent with the last 80 years implies a significantly deeper recession than any since the Great Depression. The cyclical component implied by deviations from 2% growth drops to a low of 7.3% below trend. Secondly, there is a stark difference in the movement of the series during the recovery. If one were to rely on the full HP filter trend estimates, output would look at though it has recovered back to long-term trend growth. However, this again assumes long-term trend growth is less than 1% annually. Recovery back to even 2% growth is simply nonexistent .

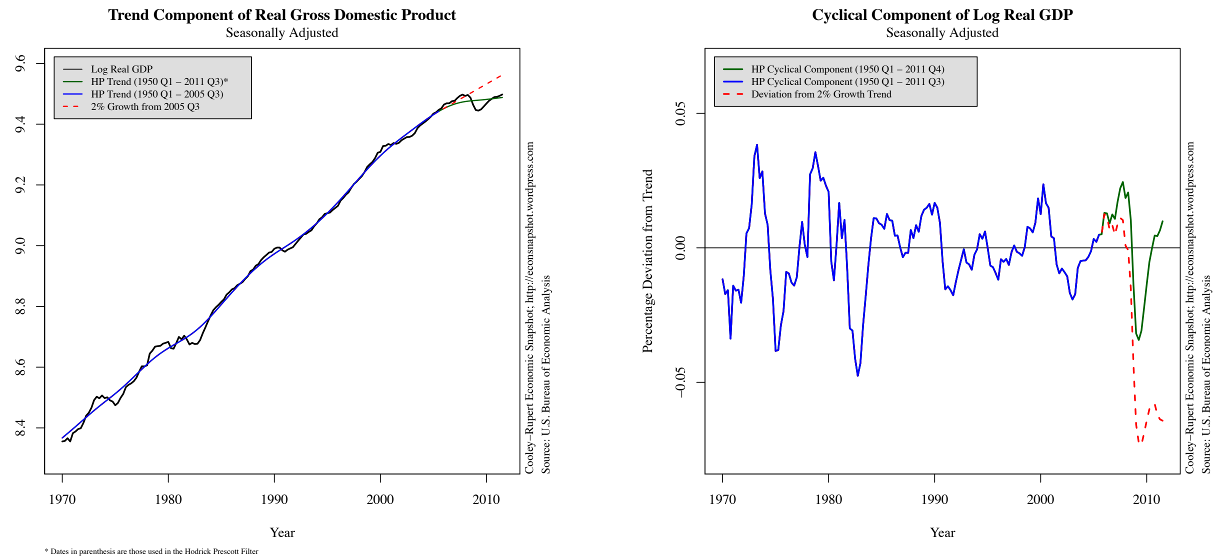

Figure 7: 2007 Cycle

3.2 1975 & 1981 Cycles

For aditional insight, we present two more experiments using the 1981 and 1973 cycles for comparison. The idea of both experiments is as follows. In the current cycle, real GDP has taken 15 quarters to reach its previous peak level. We have shown that relying on the HP filter at this point during the cycle leads to problems that we highlighted above. One may ask if these problems are unique to the current cycle. Say you were to HP filter real GDP at roughly the same point in previous cycles. Would the same problems arise? The answer is yes.

In Figure 8 and Figure 9, we cut off real GDP at the quarter that it reached its previous peak level. This corresponds to 1983 Q2 and 1975 Q4[4] and is comparable to where we are in the current cycle. We then HP filter the truncated data series to obtain the estimated long-run growth trend and compare it to the HP trend using the full data series. Finally, we compare the corresponding cyclical deviations of real GDP to both growth trends.

[4] 7 and 8 quarters after real GDP reached its peak level for the 1981 and 1973 cycle, respectively.

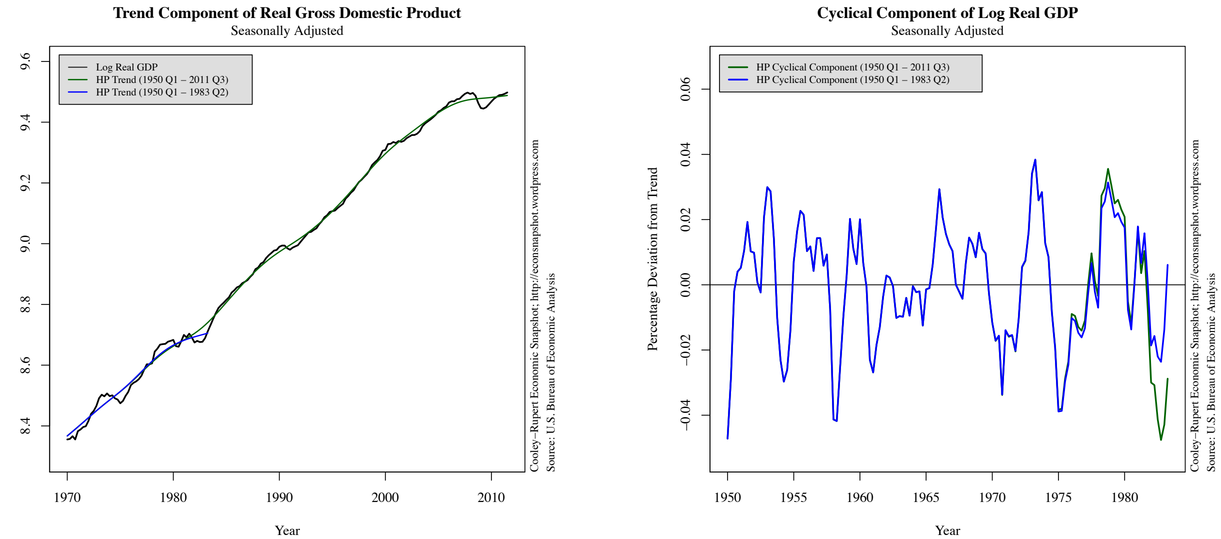

Figure 8: 1981 Cycle

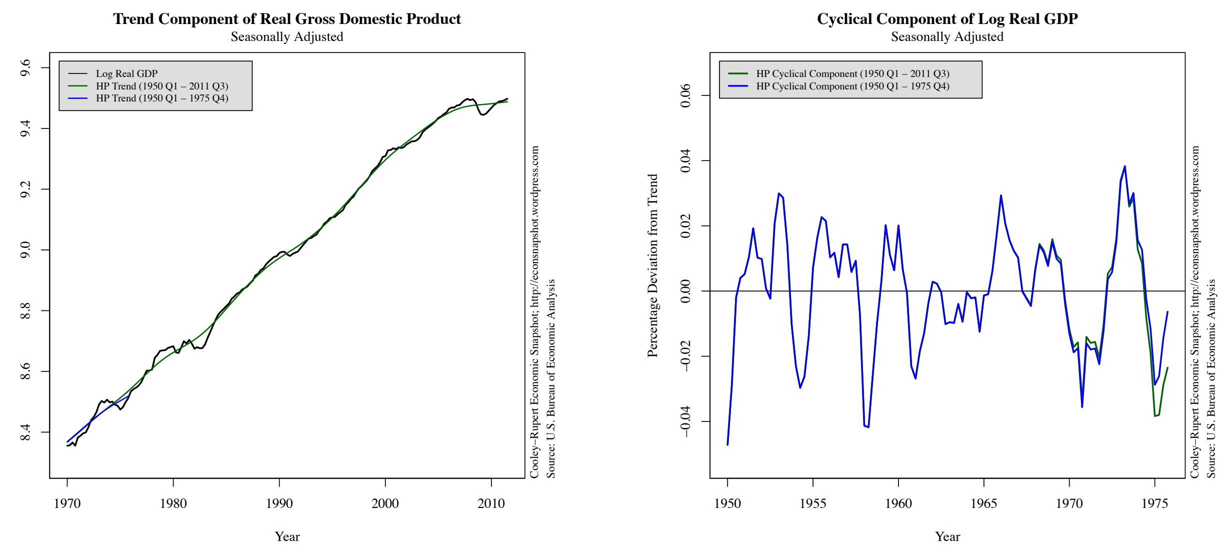

Figure 9: 1975 Cycle

These figures show that similar mistakes would be made during past cycles. The filter underestimates the depth of the cycle and overestimates its return to trend growth. The problem is endemic to the mechanical approach that relies on the end point data. As the recession is more severe, the mechanical filters are more likely to underestimate the trend. The only mechanical solution that does slightly better is the Baxter-King Symmetric bandpass filter that is less influenced by the last three years of data.

4 Severity of Cycles

Given the problems with relying on mechanical filtering discussed above, we ask if there is a more reliable metric to compare cycles? It's important to note that cycles vary along many dimensions. Some cycles are quick but deep. Other cycles are shallow but recover back to trend slowly. A desirable property, then, for any metric is to somehow capture these different dimensions.

We propose a simple and transparent way to compare the severity of cycles. The method we propose is to assume that at the peak of a business cycle, the economy would continue to grow at an average annual rate of 3%.[5] Then, we calculate the gap between this 'potential' path of output and that actually realized. The idea is to capture how costly a cycle is relative to it never occurring as well identify its different properties mentioned above.

Figure 10 shows the assumed counter-factual growth from NBER peak dates in red along with the path of logged real GDP. Despite the simplicity of the metric, it does well in capturing the different aspects of a cycle without running into the problems of estimating trend growth. In fact, the conclusions about the cycles occurring before the great recession are similar with this metric and deviations from an HP trend. It shows the two most severe cycles during this time were in 1973 and 1981, much like Figure 2 shows. Additionally, and in contrast to a filtered cyclical component, it shows that the 2007 cycle is by far the deepest and has had the slowest recovery.

The advantage of our simple metric is not only in avoiding estimation errors but that the different properties of a cycle can be clearly analyzed. Figure 11 plots the cumulative percentage of output lost relative to the 3% growth paths shown in Figure 10 in the 5 previous cycles. From peak, the 1973, 1981, and 1990 recessions were sharper than in 2007 losing output at a greater rate even four quarters in. In mid 2008 the behavior of the great recession began to differ. At this point in

[5] The average annual growth rate of the HP trend from 1950 until 2005 is 3.3%. The average annual growth rate in real GDP over the same time period was 3.1%.

other cycles the pace of output lost began to decrease. In the current recession it accelerated. Six quarters after its peak, the output lost was higher than in any past cycle since 1950. In words, the 2007 cycle was slower to evolve and deeper than either the 1973 or 1981 cycles.

The pace of the recovery can also be compared across cycles. The 1973 cycle was deep, but output recovered quickly. The 1981 cycle was just as deep as 1973, but its recovery was slower. During the last three cycles the return to a 3% growth trend at least, has been relatively non-existant. In the 1990 and 2001 cycle this behavior might not have been of much concerning since these cycles were comparatively shallow. The current recession is quite deep. Table 1 reports quarter by quarter percentage differences and Table 2 reports the cumulative difference.

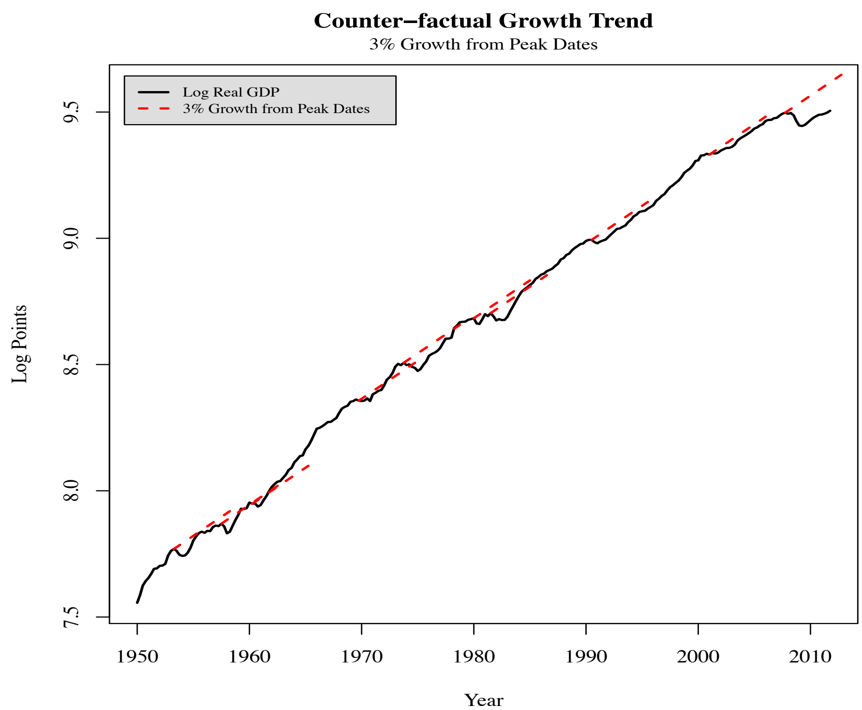

Figure 10: 3% Growth from NBER Peaks.

A potential problem in comparing output to a trend from the previous *peak* of the business cycle is that we implicitly assume that the growth in output up until the peak can be sustained. Since productivity is measured as a mean reverting process around some constant growth trend, stochastically speaking, remaining above this trend indefinitely is not sustainable. However, we in-

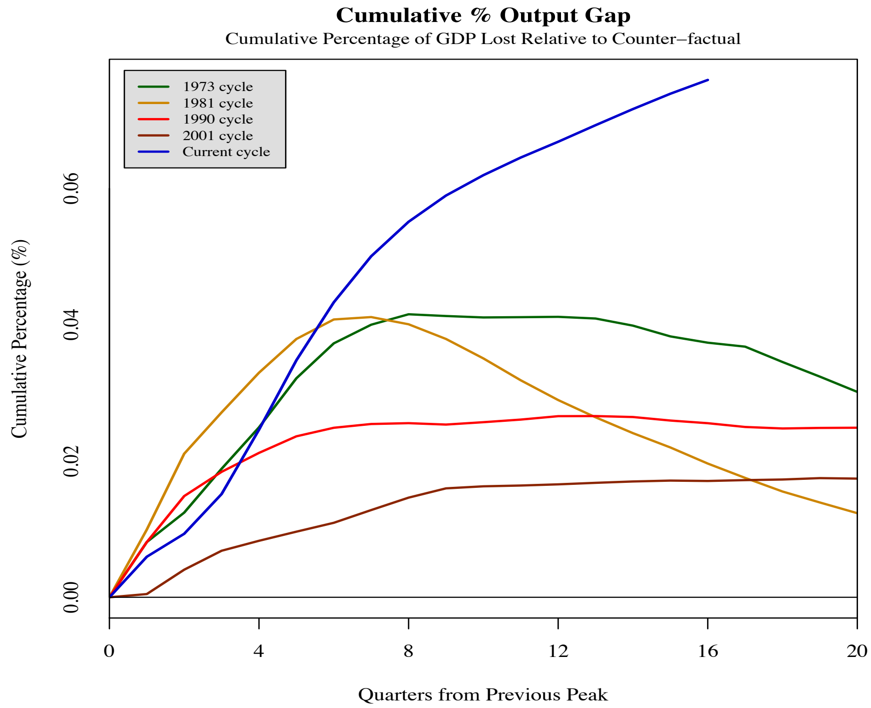

Figure 11: Cumulative % Output Lost Relative to 3% Growth from NBER Peak.

terpret our metric as an upper bound to the loss of output and remain agnostic about the underlying stochastic process of productivity and hence output.

An alternative approach to measuring the business cycle is to estimate the trend using the HP filter with a high value of λ. This limits the variability of the trend component while not imposing constant growth. Figure 12 shows the HP trend for varying values of λ. As you increase λ away from the standard business cycle value of 1600, the growth of the trend at the end of the series increases substantially.[6] Table 4 reports the cumulative percentage of output *lost* relative to the HP trend at $\lambda = 100,000$. A negative value represents that real GDP was *above* its trend while a positive value, or a positive amount of output lost, means that it was below its trend. This measure is directly comparable to the numbers given in Table 2. For comparison, Figure 13 shows both the 3% growth trends from NBER peaks as well as the HP filtered trend relative to the level of logged real GDP.

[6]Average annual growth rates in the HP trend for λ = 1,600, 10,000, 100,000, and 250,000 are 3.06%, 3.05%, 3.13%, and 3.16% respectively. Growth rates for the same values of lambda between 2005 Q1 and 2011 Q4 are 0.96%, 1.21%, 1.98%, and 2.28% respectively.

One important consequence of measuring output lost relative to this stiff HP trend is that two cycles with the same depth and duration but whose peak levels differ in relation to trend will have different costs. For example, Figure 11 and Table 2 show that the 1973 and 1981 cycles were close in terms of depth and duration. However, in Table 4 the 1981 cycle appears to be much more severe. The reason is that the peak of the 1981 cycle was significantly closer to trend than in 1973 as can be seen in Figure 13. Therefore, since these two cycles had the same depth and duration, the 1983 cycle was below trend longer than the 1973 cycle. If one wants to incorporate the position of a business cycle relative to a long term growth trend in the metric, then this last approach seems appropriate.

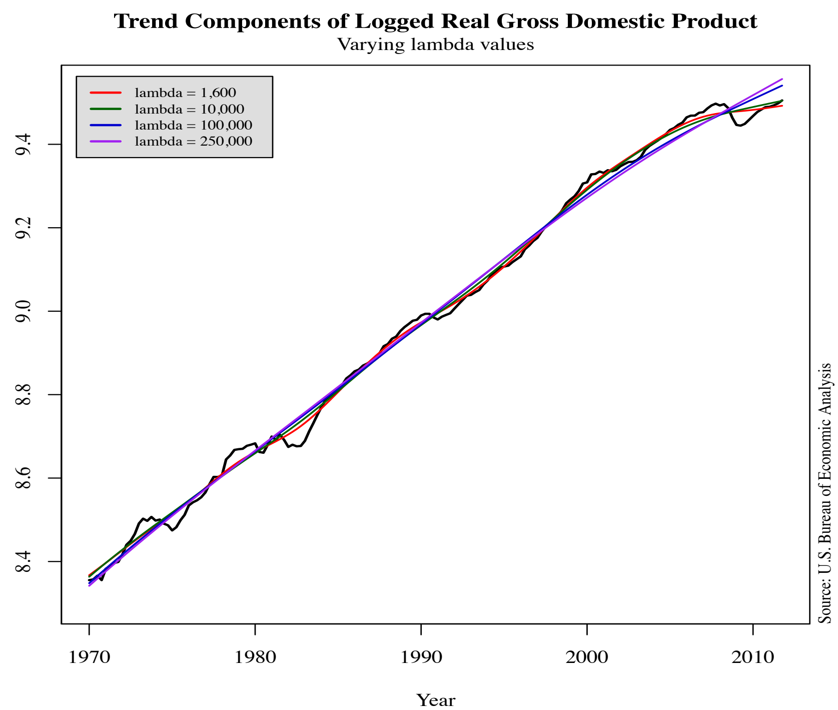

Figure 12: HP trend component of (log) real GDP using $\lambda = $ 1,600, 10,000, 100,000, and 250,000.

5 Conclusion

Caution is needed when intepreting business cycle fluctuations with a mechanical filter. They can easily overstate the decline in the growth component and thereby understate the severity of a

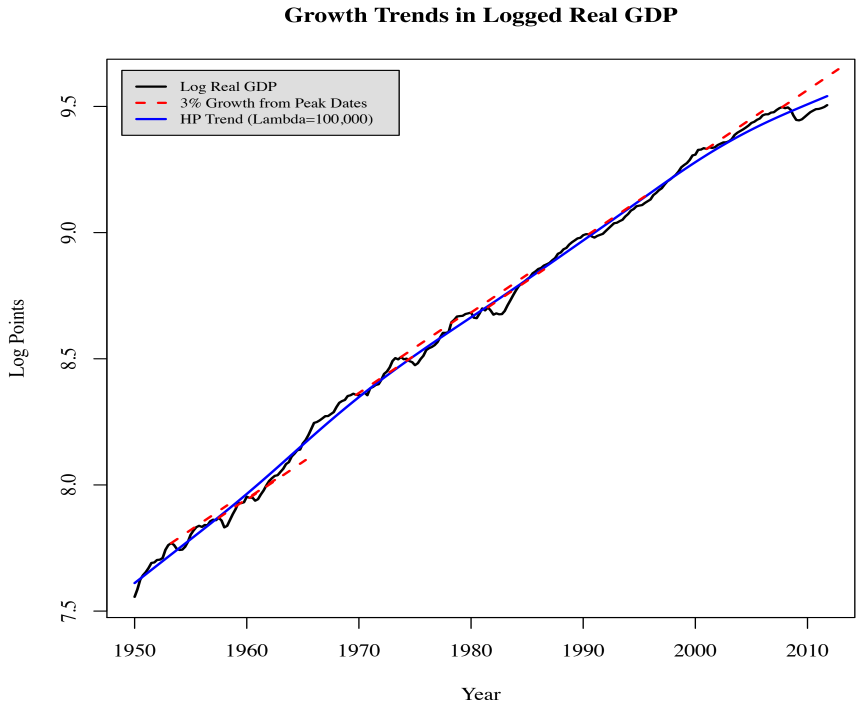

Figure 13: HP Growth Trend vs. 3% Growth Trend from Peak

cyclical downturn. The trend rate of growth may well be impaired by a sharp cycle down but both theory and history suggests that modern industrial economies tend to recover to something like a normal growth trajectory.

Table 1: Percentage of GDP Lost Relative to Counter-factual

		Quarters from Previous Peak										
		0	1	2	3	4	5	6	7	8	9	10
1953 Cycle	Real GDP	2366.2	2351.8	2314.6	2303.5	2306.4	2332.4	2379.1	2447.7	2488.1	2521.4	2535.5
	3% Growth Trend	2366.2	2383.95	2401.83	2419.84	2437.99	2456.27	2474.7	2493.26	2511.96	2530.79	2549.78
	Difference (%)	0	-1.37	-3.77	-5.05	-5.71	-5.31	-4.02	-1.86	-0.96	-0.37	-0.56
1957 Cycle	Real GDP	2616.6	2589.1	2519	2534.5	2593.9	2654.3	2708	2776.4	2773.1	2782.8	2845.3
	3% Growth Trend	2616.6	2636.22	2656	2675.92	2695.99	2716.21	2736.58	2757.1	2777.78	2798.61	2819.6
	Difference (%)	0	-1.82	-5.44	-5.58	-3.94	-2.33	-1.06	0.7	-0.17	-0.57	0.9
1960 Cycle	Real GDP	2832	2836.6	2800.2	2816.9	2869.6	2915.9	2975.3	3028.7	3062.1	3090.4	3097.9
	3% Growth Trend	2832	2853.24	2874.64	2896.2	2917.92	2939.8	2961.85	2984.07	3006.45	3029	3051.71
	Difference (%)	0	-0.59	-2.66	-2.82	-1.68	-0.82	0.45	1.47	1.82	1.99	1.49
1969 Cycle	Real GDP	4259.6	4252.9	4260.7	4298.6	4253	4370.3	4395.1	4430.2	4442.5	4521.9	4629.1
	3% Growth Trend	4259.6	4291.55	4323.73	4356.16	4388.83	4421.75	4454.91	4488.32	4521.99	4555.9	4590.07
	Difference (%)	0	-0.91	-1.48	-1.34	-3.19	-1.18	-1.36	-1.31	-1.79	-0.75	0.84
1973 Cycle	Real GDP	4948.8	4905.4	4918	4869.4	4850.2	4791.2	4827.8	4909.1	4973.3	5086.3	5124.6
	3% Growth Trend	4948.8	4985.92	5023.31	5060.99	5098.94	5137.18	5175.71	5214.53	5253.64	5293.04	5332.74
	Difference (%)	0	-1.64	-2.14	-3.93	-5.13	-7.22	-7.21	-6.22	-5.64	-4.06	-4.06
1980 Cycle	Real GDP	5903.4	5782.4	5771.7	5878.4	6000.6	5952.7	6025	5950	5852.3	5884	5861.4
	3% Growth Trend	5903.4	5947.68	5992.28	6037.23	6082.5	6128.12	6174.08	6220.39	6267.04	6314.05	6361.4
	Difference (%)	0	-2.86	-3.82	-2.7	-1.36	-2.95	-2.47	-4.54	-7.09	-7.31	-8.53
1981 Cycle	Real GDP	6025	5950	5852.3	5884	5861.4	5866	5938.9	6072.4	6192.2	6320.2	6442.8
	3% Growth Trend	6025	6070.19	6115.71	6161.58	6207.79	6254.35	6301.26	6348.52	6396.13	6444.1	6492.43
	Difference (%)	0	-2.02	-4.5	-4.72	-5.91	-6.62	-6.1	-4.55	-3.29	-1.96	-0.77
1990 Cycle	Real GDP	8052.6	7982	7943.4	7997	8030.7	8062.2	8150.7	8237.3	8322.3	8409.8	8425.3
	3% Growth Trend	8052.6	8112.99	8173.84	8235.15	8296.91	8359.14	8421.83	8484.99	8548.63	8612.75	8677.34
	Difference (%)	0	-1.64	-2.9	-2.98	-3.31	-3.68	-3.33	-3.01	-2.72	-2.41	-2.99
2001 Cycle	Real GDP	11287.8	11361.7	11330.4	11370	11467.1	11528.1	11586.6	11590.6	11638.9	11737.5	11930.7
	3% Growth Trend	11287.8	11372.46	11457.75	11543.69	11630.26	11717.49	11805.37	11893.91	11983.12	12072.99	12163.54
	Difference (%)	0	-0.09	-1.12	-1.53	-1.42	-1.64	-1.89	-2.62	-2.96	-2.86	-1.95
2007 Cycle	Real GDP	13326	13266.8	13310.5	13186.9	12883.5	12663.2	12641.3	12694.5	12813.5	12937.7	13058.5
	3% Growth Trend	13326	13425.95	13526.64	13628.09	13730.3	13833.28	13937.03	14041.55	14146.87	14252.97	14359.87
	Difference (%)	0	-1.2	-1.62	-3.35	-6.57	-9.24	-10.25	-10.61	-10.41	-10.17	-9.97

Table 2: Cumulative % of GDP Lost Relative to Counter-factual

	Quarters from previous peak									
	1	2	3	4	5	6	7	8	9	10
1953 cycle	0.007	0.017	0.025	0.031	0.034	0.035	0.033	0.030	0.027	0.025
1957 cycle	0.009	0.023	0.031	0.032	0.031	0.028	0.023	0.021	0.019	0.017
1960 cycle	0.003	0.011	0.015	0.015	0.014	0.011	0.008	0.005	0.002	0.001
1969 cycle	0.005	0.008	0.009	0.014	0.013	0.013	0.013	0.014	0.013	0.011
1973 cycle	0.008	0.012	0.019	0.025	0.032	0.037	0.040	0.042	0.041	0.041
1980 cycle	0.014	0.022	0.023	0.021	0.022	0.023	0.025	0.030	0.034	0.038
1981 cycle	0.010	0.021	0.027	0.033	0.038	0.041	0.041	0.040	0.038	0.035
1990 cycle	0.008	0.015	0.018	0.021	0.024	0.025	0.025	0.026	0.025	0.026
2001 cycle	0.000	0.004	0.007	0.008	0.010	0.011	0.013	0.015	0.016	0.016
Current cycle	0.006	0.009	0.015	0.025	0.035	0.043	0.050	0.055	0.059	0.062

	Quarters from previous peak									
	11	12	13	14	15	16	17	18	19	20
1953 cycle	0.024	0.024	0.024	0.024	0.023	0.024	0.024	0.025	0.028	0.030
1957 cycle	0.015	0.015	0.016	0.017	0.017	0.017	0.016	0.014	0.013	0.011
1960 cycle	-0.001	-0.003	-0.006	-0.008	-0.011	-0.014	-0.017	-0.019	-0.022	-0.025
1969 cycle	0.009	0.007	0.004	0.000	-0.002	-0.003	-0.004	-0.004	-0.004	-0.003
1973 cycle	0.041	0.041	0.041	0.040	0.038	0.037	0.037	0.035	0.032	0.030
1980 cycle	0.042	0.045	0.047	0.047	0.047	0.046	0.045	0.043	0.042	0.041
1981 cycle	0.032	0.029	0.026	0.024	0.022	0.020	0.018	0.016	0.014	0.012
1990 cycle	0.026	0.027	0.027	0.026	0.026	0.026	0.025	0.025	0.025	0.025
2001 cycle	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Current cycle	0.065	0.067	0.069	0.072	0.074	0.076				

*Percentages in red denote NBER trough dates.

Table 3: Cumulative GDP Lost Relative to Counter-factual (2005 Prices)

	Quarters from previous peak									
	1	2	3	4	5	6	7	8	9	10
1953 cycle	8.0	29.8	58.9	91.8	122.8	146.7	158.1	164.0	166.4	170.0
1957 cycle	11.8	46.0	81.4	106.9	122.4	129.5	124.7	125.9	129.8	123.4
1960 cycle	4.2	22.8	42.6	54.7	60.6	57.3	46.1	32.2	16.9	5.3
1969 cycle	9.7	25.4	39.8	73.8	86.6	101.6	116.1	136.0	144.5	134.7
1973 cycle	20.1	46.5	94.4	156.5	243.0	330.0	406.4	476.5	528.1	580.2
1980 cycle	41.3	96.5	136.2	156.6	200.5	237.8	305.4	409.1	516.6	641.6
1981 cycle	30.0	95.9	165.3	251.9	349.0	439.6	508.6	559.6	590.6	603.0
1990 cycle	32.7	90.4	149.9	216.4	290.7	358.5	420.4	477.0	527.7	590.7
2001 cycle	2.7	34.5	77.9	118.7	166.1	220.8	296.6	382.7	466.5	524.7
Current cycle	39.8	93.8	204.1	415.8	708.3	1032.3	1369.0	1702.4	2031.2	2356.5

	Quarters from previous peak									
	11	12	13	14	15	16	17	18	19	20
1953 cycle	181.2	192.3	209.1	220.3	232.5	251.3	268.8	298.3	350.3	403.6
1957 cycle	125.6	132.0	152.8	174.8	189.2	197.4	196.4	187.5	175.9	162.9
1960 cycle	-10.6	-30.6	-59.8	-89.3	-131.2	-176.7	-227.7	-275.0	-337.3	-405.4
1969 cycle	122.5	99.6	55.2	5.4	-28.9	-66.0	-83.2	-94.5	-84.5	-60.5
1973 cycle	635.9	692.4	744.0	779.7	801.8	834.6	873.2	868.6	860.7	844.5
1980 cycle	777.3	906.9	1015.2	1105.8	1176.6	1229.2	1266.4	1300.3	1333.4	1363.5
1981 cycle	599.7	592.9	584.9	573.6	560.6	533.8	506.5	475.4	450.2	421.0
1990 cycle	656.5	727.6	787.0	842.0	884.0	928.6	965.5	1014.1	1075.1	1134.5
2001 cycle	578.8	636.0	696.8	758.3	818.1	869.7	931.2	991.8	1060.3	1113.0
Current cycle	2688.5	3028.5	3392.9	3773.8	4167.6	4566.5				

*Percentages in red denote NBER trough dates.

Table 4: Cumulative % of GDP Lost Relative to HP trend with $\lambda = 100,000$

	Quarters from previous peak									
	1	2	3	4	5	6	7	8	9	10
1953 cycle	-0.038	-0.027	-0.018	-0.011	-0.007	-0.006	-0.008	-0.010	-0.012	-0.013
1957 cycle	0.013	0.028	0.036	0.038	0.037	0.035	0.032	0.030	0.029	0.028
1960 cycle	0.028	0.037	0.042	0.043	0.043	0.042	0.039	0.038	0.036	0.036
1969 cycle	-0.013	-0.008	-0.006	-0.001	-0.001	-0.000	0.000	0.001	0.001	-0.000
1973 cycle	-0.025	-0.020	-0.013	-0.007	0.001	0.007	0.010	0.011	0.011	0.011
1980 cycle	-0.005	0.003	0.004	0.002	0.003	0.003	0.006	0.011	0.015	0.019
1981 cycle	0.015	0.026	0.032	0.037	0.042	0.045	0.046	0.045	0.042	0.040
1990 cycle	-0.001	0.006	0.010	0.013	0.015	0.017	0.017	0.018	0.018	0.018
2001 cycle	-0.024	-0.021	-0.018	-0.017	-0.016	-0.015	-0.014	-0.013	-0.012	-0.012
Current cycle	-0.028	-0.025	-0.021	-0.012	-0.003	0.004	0.010	0.014	0.017	0.018

	Quarters from previous peak									
	11	12	13	14	15	16	17	18	19	20
1953 cycle	-0.013	-0.013	-0.013	-0.012	-0.012	-0.011	-0.010	-0.008	-0.005	-0.001
1957 cycle	0.027	0.028	0.030	0.032	0.033	0.033	0.033	0.033	0.032	0.032
1960 cycle	0.035	0.034	0.033	0.032	0.030	0.029	0.027	0.026	0.024	0.023
1969 cycle	-0.002	-0.004	-0.007	-0.009	-0.011	-0.012	-0.012	-0.012	-0.011	-0.010
1973 cycle	0.011	0.011	0.011	0.010	0.009	0.008	0.007	0.005	0.003	0.001
1980 cycle	0.023	0.026	0.028	0.029	0.028	0.027	0.026	0.024	0.023	0.022
1981 cycle	0.036	0.034	0.031	0.029	0.027	0.025	0.023	0.021	0.019	0.018
1990 cycle	0.019	0.019	0.020	0.020	0.019	0.019	0.019	0.019	0.019	0.019
2001 cycle	-0.012	-0.013	-0.013	-0.014	-0.014	-0.015	-0.016	-0.016	-0.017	-0.018
Current cycle	0.020	0.021	0.022	0.023	0.024	0.024				

*Percentages in red denote NBER trough dates.

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