The Dynamics of Recoveries

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The Dynamics of Recoveries

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Abstract

In this paper, we examine whether the early stages of an expansion are different from its later stages. We find that growth in aggregate output is higher in the early stages of an expansion than in the later stages. We term this a recovery effect. In addition to finding a recovery effect for output, we find that the shape of the business cycle is characterized by concave expansions--output grows at a slower rate later in the expansion than in the beginning of the expansion--and linear recessions--the rate of contraction is not significantly different over the course of the recession. The high growth during the recovery seems to be associated with high inventory investment, purchases of consumer durables, and investment in residential structures. We also find that the strength of the recovery depends, in part, on the depth of the preceding recession. This bounce-back result is quite robust across alternative business cycle dates. In Monte Carlo analyses, we show that linear time series models are unable to generate significant bounce-back effects or replicate the actual shape of the business cycle.

1. Introduction

Is the course of an expansion influenced in any way by the character of the preceding recession? In particular, does the economy "recover" from a recession and does the strength this recovery depend on the severity of the prior recession? The notion that there is a period of recovery that is distinct from the rest of an expansion is implicit in a variety of models of the business cycle. One of the earliest explicit statements of this idea in the academic literature is Friedman (1969), who asked whether "... the magnitude of an expansion [is] systematically related to the magnitude of the succeeding contraction? Does a boom tend on the average to be followed by a large contraction? A mild expansion, by a mild contraction?"(p.271). On the basis of simple rank correlation coefficients, he found no systematic connection between the size of an expansion and that of the subsequent contraction, but did find that "a large contraction in output tends to be followed on the average by a large business expansion; a mild contraction, by a mild expansion." Friedman (1993) reiterated these findings and presented some additional evidence consistent with the "plucking model" of fluctuations.[2] Moore (1965) also pointed out that "...rates of increase during the initial stages of recovery [are] generally larger following severe contractions than following mild ones...[and] that initial rates of increase (during, say, the first six to twelve months) usually exceed those at any subsequent time during the business expansion..." (p.503).

In a real business cycle model (see for example King, Plosser and Rebelo (1988) and Kydland and Prescott (1982)) a recession comes about as a result of some adverse real shock that knocks the economy away from its long run

[2]On the plucking model, see also Goodwin and Sweeney (1993).

equilibrium growth path. Recovery from the recession then follows the course of a return to steady state equilibrium. The dynamics of the recovery are essentially the same as the transitional dynamics of the standard neoclassical Solovian growth model. The economy grows more rapidly the further the capital stock is from its long run equilibrium level. Consequently, large technology shocks that are absorbed in part by running down the capital stock should be followed by periods of rapid growth.

In the older natural rate literature, recessions are seen as deviations from long-run potential or the natural rate of output. Recoveries are then driven by a "catch-up" effect as inventory adjustment takes place, wages adjust, and pent-up consumer demand becomes satisfied.

It is also common in both the academic and popular literature to see recessions referred to as "purgative" episodes where "excesses" of one sort or another are "cleansed" from the economy, and are followed by periods of rapid growth as a result of this cleansing.[3] Popular statements of this idea are Blinder (1984,1989,1991), who termed it the "Joe Palooka" effect.

This paper starts with an investigation of the behavior of the growth rate of output, as measured by real GNP and industrial production, over the course of the business cycle. We adopt the concept of business-cycle time introduced by Burns and Mitchell (1946), dividing recessions and expansions in calendar time into separate business cycle "phases". Using this framework, we show that growth in the first phase of an expansion (i.e. immediately following a business cycle trough) is significantly greater than growth during the subsequent stages of the cycle. This suggests that there is something

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[3]See for example the recent papers by Caballero and Hammour (1991) and Aghion and Saint-Paul (1991).

different about the early stages of an expansion. We also find that the "shape" of expansions tends to be concave, while recessions are "linear". That is, growth tends to be faster than average earlier in the expansion and slower than average later in the expansion, while the rate of decline during a recession is not significantly different over the course of the recession.

In section 3, we examine the behavior of the major components of aggregate output and find that consumer durables, residential construction, inventory investment, productivity and M2 exhibit strong recovery effects, while variables such as nondurable and services consumption, prices, and the monetary base show no evidence of a recovery effect.

We then go on to investigate whether the strength of the recovery is influenced by the severity of the prior recession. Specifically, we consider the notion that the economy tends to bounce back from recessions - the more severe the recession, the more vigorous the recovery.[4] We examine a variety of production measures for the United States that allow us to include recessions as far back as the late nineteenth century. We show that growth in the early stages of an expansion tends to be greater the more severe the preceding recession, where severity is measured as the cumulative output loss over the course of the recession.

In section 5 we go on to consider the question of whether some simple linear time series models that are commonly used to describe output are capable of replicating the behavior of output during the different phases of the cycle and the bounce-back phenomenon. On the basis of Monte Carlo experimentation, we conclude that none of the linear models we consider are

[4] An obvious corollary that we do not consider in this paper is that expansions contain the seeds of the subsequent recession.

capable of replicating these phenomena. Section 6 concludes.

2. Is there a recovery?

The notion of a recovery, and indeed the name, suggests a response or adjustment to periods of recession. Not all conceptions of the business cycle necessarily imply a recovery. For example, if recessions and expansions are draws from a two-state Markov model as in Hamilton (1989), then the notion of a recovery is not empirically relevant. In this section, we examine whether the economy behaves differently immediately after a recession than during other periods of an expansion.

2.1 Post-World War II business cycles

To determine whether a separate period of recovery exists, we examine whether the growth rate of output is significantly greater early in an expansion than in its later stages. We consider two ways to break up the cycle. First, we divide the business cycle into a recession phase, a recovery phase which we arbitrarily define to be the twelve months following the trough date, and a phase that represents the rest of the expansion. We also divide the business cycle using the eight-phase classification of Burns and Mitchell (1946). In this classification, the first phase is three months centered on the initial trough, while the fifth phase is the three months centered on the subsequent peak. The second, third and fourth phases break the expansion into three intervals of equal length, while the sixth, seventh and eighth phases break the subsequent recession into three intervals of equal length.[5] The

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[5] For quarterly data, we take the phase 1 to be the quarter of the trough and phase 5 to be the quarter of the subsequent peak. Burns and Mitchell have a ninth phase which is the three months centered on the next trough. This is also the first phase of the next business cycle.

Burns and Mitchell phases allow for the possibility that business cycles evolve according to economic or business cycle time (Stock (1987)) rather than calendar time. If the economy does indeed "recover" from a recession, then the growth rate in output should be greater in the first year of the expansion than during the rest of the expansion, and greater in the second phase of the business cycle (the first third of the recovery) than in the third and fourth phases.

To test whether recoveries are different from the rest of the expansion, we simply regress the growth rate of output against dummy variables that break business cycle into the different phases described above.[6] The coefficients represent the average growth rate of output during the different phases of the business cycle. The NBER business cycle chronology (see Moore and Zarnowitz (1986)) is used to determine peak and trough dates. We use quarterly real GNP and the monthly Federal Reserve Index of Industrial Production as measures of output. We set the trough of the most recent recession as May 1991. The choice of the date for the last trough does not affect the results for the recovery stages since our sample ends with the trough of most recent recession. To correct for possible heteroskedasticity and serial correlation, we employ the White (1980) consistent covariance matrix estimator with the Newey-West (1987) correction for serial correlation.[7]

Table 1 presents the results of the growth rates of real GNP and Industrial Production over the 1947-1991 period regressed against the various phase dummies. Along with the coefficient estimates for the phases, p-values

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[6] See Appendix A for details of how the phase dummies were set.

[7] The window length for the Newey-West correction was set at twenty-four for monthly data and eight for quarterly data. The ROBUSTERRORS option in RATS was used to calculate the covariance matrix.

for various one-sided and two-sided tests are also presented. Both real GNP and industrial production show evidence of a recovery effect. The growth rates of real GNP and industrial production are significantly higher in the first year of the recovery as compared to the rest of the expansion. Similarly, the growth rate in the first third of the expansion (phase 2) is significantly greater than growth in either the third or fourth phases of the business cycle for industrial production and real GNP.[8] Thus, output appears to grow faster in the early phases of an expansion than in the later phases of the expansion.

These results are similar to those of Sichel (1992) who examined quarterly real GNP. He broke the business cycle into a recession phase, a recovery phase, and a rest-of-expansion phase as in our three-phase characterization and considered different lengths for the recovery phase. Like us, he found a significant recovery effect and argued for a three-phase characterization of the business cycle that includes a high growth recovery phase. While our results support the notion of a recovery phase, the Burns and Mitchell phase results suggest that real GNP and industrial production are concave over the expansion (the growth rate of output in phase 2 is greater than the growth rate of output in phase 3 which in turn is greater than the growth rate of output in phase 4); that is, the growth of output declines in the later stages of the expansion. The three-phase characterization captures part of this concavity but not all of it. Also note that in addition to a recovery effect and a slowdown effect, output appears to linear over the recession as the growth rate does not significantly differ across the

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[8] The results are essentially unchanged if we control for secular trends by extracting average growth rate over the business cycle (the peak to peak growth rate) before running the phase regressions.

recession phases. Thus, the Burns and Mitchell phase regressions imply that the "shape" of the business cycle is characterized by concave expansions and linear recessions.

2.2 Pre-World War II business cycles

In order to increase number of business cycles in the sample, we extend our analysis to include pre-World War II data. While quarterly real GNP data do not extend back before WWII, the Federal Reserve Index of Industrial Production series starts in 1919. In addition, we examine the monthly industrial production index of Miron and Romer (1990) which runs from 1884 to 1940. Unfortunately, the Miron-Romer series is not strictly comparable to the Federal Reserve's Index of Industrial Production; therefore, we use an approximation to the Miron-Romer series a series suggested by Watson (1992) for the postwar period.

Table 2 presents phase regressions based on the NBER chronology for the Miron-Romer and Federal Reserve industrial production indices.[9] Adding the interwar period to the Fed's IP series does not alter the basic results presented above. Output growth is higher in the early stages of a recovery than later in the expansion. Similarly, the "shape" of output over the business cycle for the extended sample is concave during expansions and linear during recessions. The Miron-Romer series also exhibits significantly higher growth early in the expansion; however, the "shape" of the Miron-Romer series

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[9] The Miron-Romer is seasonally adjusted using the exponential smoothing (ESMOOTH) procedure in RATS. The Miron-Romer data underlying the results in Table 2 are controlled for multiplicative seasonality. When additive seasonality is controlled, we obtain essentially the same results. Similarly, if we seasonally adjust the Fed IP Index ourselves, we obtain the essentially the same results as using the officially seasonally adjusted Fed IP index.

is not concave over the expansion since growth in phase 3 is less than phase 4. Watson's extended Miron-Romer series also shows strong evidence of a recovery effect in the post-World War II period.

2.3 Alternative business cycle dates

Recently, Romer (1992) and Watson (1994) have questioned the validity of NBER reference cycle dates for the pre-World War I era. For example, Miron-Romer index posts notable increases during three pre-WWI recessions, as well as during the 1918-1919 recession. This is in marked contrast to the behavior of industrial production as measured by the Fed's index during post-WWI recessions. This may reflect a problem with the coverage of the Miron-Romer index, or it may indicate problems with the NBER dates for business cycle peaks and troughs. These dates are subjectively determined by a committee of experts in a manner that is not easily replicated. An alternative procedure for picking peaks and troughs in measures of economic activity is that of Bry and Boschan (1971), which was originally devised as a way of formalizing the various informal rules used by NBER researchers for dating business cycles. To investigate the robustness of our results to the choice of dates, we used the algorithm developed by Bry and Boschan (1971) to determine the turning points. The algorithm involves finding peaks and troughs of a smoothed version of the time series subject to restrictions on the length of the entire cycle and on the length of expansion and recession phases.

Table 3 presents business cycle dates when the Bry and Boschan algorithm is applied to Fed IP Index and to the Miron-Romer and extended Miron-Romer series. Using the Fed IP index the Bry-Boschan algorithm selects turning points that are roughly comparable to the NBER dates with the exception that the 1980 recession is missed by the Bry-Boschan algorithm. On the other hand, the Bry-Boschan algorithm when applied to Miron-Romer data results in a very different business cycle chronology than the NBER chronology. The Bry-Boschan algorithm identifies three entire cycles not listed in the NBER chronology. In addition, several peak and trough dates are hard to reconcile with the NBER dates. For example, June 1897 is a trough in the NBER chronology while the Bry-Boschan algorithm selects July 1897 as a peak in the Miron-Romer data. Similarly, July 1902 is identified by the Bry-Boschan algorithm as a trough in the Miron-Romer data while September 1902 is identified as a peak in the NBER chronology. The Bry-Boschan algorithm applied to Watson's post war extension of the Miron-Romer series also results in a different business cycle chronology than the NBER chronology. In fact, there are six more cycles indicated by the Bry-Boschan algorithm in the extended Miron-Romer series not listed in the NBER chronology--three of the cycles are in the 1980s.

The phase regressions run using the Bry-Boschan dates are presented in Table 4. For the Fed IP index from 1947:1 to 1991:6, the Bry-Boschan dates do not change essence of the results above; output growth in early phase of the expansion is significantly greater than in the rest of the expansion. Similarly, the Bry-Boschan chronology for the Fed IP index from 1919:1 to 1991:6 implies a strong recovery effect. With the Miron-Romer data and the Bry-Boschan dates growth during the first year of the expansion is still significantly greater than growth during the rest of the expansion, but growth in the Burns and Mitchell expansion phases are not significantly different from one another. The extended Miron-Romer data does, however, show stronger evidence of a recovery effect.

In conclusion, there appears to evidence that output grows faster early in the expansion than in later phases of the expansion, particularly in the postwar period. This suggests that the economy does "recover" from a recession. In addition, real GNP and the Federal Reserve Industrial Production Index are concave over the expansion with output growth decreasing over the course of the expansion. Evidence for a recovery phase is slightly weaker in the Miron-Romer industrial production data.

3. Phase behavior of other series

In this section, we examine the behavior of components of real GNP as well as other variables to look for clues about what could account for the rapid growth in output during the early stages of an expansion. Sichel (1992) finds that while real GNP experiences higher growth early in an expansion, this is not the case for final sales, which suggests that inventory investment accounts for the rapid growth early in the expansion. While we confirm Sichel's results for final sales, we also find that investment by consumers, in the form of purchases of consumer durables and investment in residential structures, also exhibits a strong recovery effect.

Table 5 presents phase regressions for the components of real GNP.[10] While the growth in consumption expenditures on nondurables and services does not appear to be substantially higher immediately following a recession than during the rest of the expansion, spending on consumer durables does show a strong recovery effect. Similarly, total investment exhibits extremely strong growth during phase 2 of the business cycle. However, the recovery effect for

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[10] Removing the peak to peak growth rates to account for the possibility of changes in the secular trend does not substantially effect the results presented below.

investment appears to be due primarily to inventory investment and residential structures.[11] Producers durable equipment (PDE) displays a relatively small recovery effect, while for nonresidential structures there is no evidence of a recovery effect. Producers durable equipment does show a prominent slowdown effect with the growth in the last third of the expansion (phase 4) significantly lower than the previous two-thirds of the expansion.

While inventory investment and investment by consumers experience higher growth immediately after the recession than in the rest of the expansion, government expenditures, exports, final sales show no evidence of a recovery effect. The phase regression for imports indicates a marginally significant recovery effect; however, this would tend to diminish the recovery effect in real GNP.

Table 6 presents phase regressions for output, labor productivity, hours, and real compensation for the manufacturing sector. Both output and productivity show strong and significant evidence of a recovery effect. The three phase regression for hours indicates a significant recovery effect while the Burns and Mitchell phases indicate only a marginally significant recovery effect. The strong recovery effect in productivity and the marginal recovery effect in hours give rise to a strong recovery effect for output. Real compensation, however, does not show significant evidence of a recovery effect. We also considered (but do not report) the same variables for the non-farm business sector and found essentially the same results; output and productivity show strong recovery effects, hours less so, and real compensation not at all.

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[11] When the phase regressions were run on fixed investment, we still find evidence of a recovery effect, albeit not as large as in total investment.

Finally, Table 7 presents phase regressions for a variety of other macroeconomic time series. Nonagricultural employment does not show a significant recovery effect. This result and those for productivity and hours suggest that much of the high growth during the recovery is due to increases in productivity and intensity of work effort (in the form of increases in hours) rather than to firms adding more workers. Employment does show a significant slowdown effect with employment growth significantly lower at the end of the expansion than during the earlier phases of the expansion.

Aggregate price indices such as the fixed-weight GNP deflator and the CPI also show no evidence of a recovery effect. In fact, these series are essentially *convex* over the expansion; that is, inflation is higher in the later phases of the expansion than in the early phases of the expansion. Combining the convex shape of prices over the expansion and the concave shape of output over the expansion is consistent with the finding of Cooley and Ohanian (1991) that inflation and output growth are negatively correlated during the postwar period. These results are, however, also consistent with the old notion of a convex aggregate supply curve. That is, as output gets close to potential, increases in aggregate demand are reflected primarily in increases in prices and less so in output. If, on the other hand, there is substantial slack in the economy due to a recession, increases in aggregate demand are reflected primarily in increases in output and less so in prices.

As for monetary aggregates, M2 growth shows strong evidence of a recovery effect.[12] On the other hand, the adjusted monetary base shows no

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[12] Using an entirely different methodology, Balke and Fomby (1994) found evidence of a recovery effect for M2. Estimating an ARIMA model for M2, they found large positive outliers in the first quarter of the expansion for four of the eight post war business cycles.

tendency for faster growth early in the expansion. This suggests that the money multiplier accounts for the higher than average growth in M2 during the recovery and supports the endogenous money arguments of Plosser (1991). Finally, we examine the growth rate of stock prices and the interest rate spread between ten year Treasury bonds and three month T-bills. Both variables seem to be leading indicators with the greatest growth in stock prices occurring during the trough phase (phase 1) while we see a inverted yield curve during the peak phase (phase 5) and the largest spreads during the trough phase and the first phase of the recovery.

4. Is there a bounce-back effect?

To test for the existence of a bounce-back effect, we consider a simple empirical model that expresses growth in the early stages of an expansion as a function of three characteristics of the preceding recession. The variables we consider are measures of the depth, length and steepness of the recession. This builds on results reported in an earlier paper (Wynne and Balke (1992)) where we looked at growth during the first twelve months of an expansion as a function of the cumulative output decline over the course of the prior recession.[13]

Our choice of recessions as the unit of observation creates serious problems in terms of sample size: in the post-WWII period there have only been nine recessions in the United States (including the most recent 1990-91 recession). To obtain a reasonably-sized sample we focus on industrial production, which is available for a longer period at the required frequency

[13]Some of the results in this section are reported in Wynne and Balke (1993).

(i.e. monthly or quarterly) than the national accounts aggregates. The Federal Reserve's index of industrial production starts in 1919, which extends the sample to 15 recessions. Adding the Miron-Romer industrial production series increases the sample size to 27 recessions. Using both the Fed and the Miron-Romer index, as well as the principal sub-components of the Fed index (manufacturing, durables manufacturing and non-durables manufacturing) we find strong evidence that growth in the early stages of a recovery is significantly influenced by the severity of the prior recession. This finding is robust to the omission of the Great Depression from the sample.

4.1 Empirical model

The model estimated in Wynne and Balke (1992) related (cumulative) growth over the first "k" months of an expansion to the (cumulative) decline in output over the course of the prior recession. This can be written in log terms as

$$(y_{T_i+k} - y_{T_i}) = \alpha_0 + \alpha_1(T_i - P_i) + \alpha_2(y_{T_i} - y_{P_i}) + \epsilon_i$$

where y_t denotes the log of output at date t, P_i is the date of the peak denoting the onset of the i'th recession, and T_i is the date of the trough denoting the end of the i'th recession. This can be rewritten as

$$g_i\ (k) = \alpha_0 + \alpha_1(T_i - P_i) + \alpha_2 s_i(T_i - P_i) + \epsilon_i$$

where $g_i(k)$ is average monthly growth rate during the first k months of the expansion and s_i is the average monthly change in output over the course of the i'th recession. It is useful to think of s_i as a measure of the "steepness" of the decline in output over the course of a recession. The "depth" of the recession, as measured by the difference between output at the peak and trough dates, can be written as $d_i = s_i(T_i - P_i)$.

This model suggests a more general model of the form

$$g_i\ (k) = \alpha_0 + \alpha_1 s_i + \alpha_2 (T_i - P_i) + \alpha_3 s_i (T_i - P_i) + \epsilon_i \tag{1}$$

This model relates growth in the first k months of an expansion to three characteristics of the prior recession, namely the steepness of the recession as measured by s_i, its length as measured by $(T_i - P_i)$, and its depth as measured by $d_i = s_i(T_i - P_i)$.

We can also specify a model that relates growth in the early stages of a recovery to these three characteristics of the prior recession in terms of detrended output. This means that we replace the dependent variable in the above specification with growth in detrended output over the first h months, measure steepness in terms of the rate of decline of detrended output over the course of the recession, and measure depth as the deviation of output from trend at the trough. This yields the specification

$$(g_i - r_i)\ (k) = \alpha_0 + \alpha_1 (s_i - r_i) + \alpha_2 (T_i - P_i) + \alpha_3 (s_i - r_i)(T_i - P_i) + \epsilon_i \tag{2}$$

where r_i is the peak-to-peak growth rate over the i'th cycle.

4.2 Results for the United States

Table 8 presents OLS estimates of equation (1) above using industrial production as the measure of output. The sample period runs from 1919 to 1990, which includes 14 recessions starting with the recession of 1920:01-1921:07 and ending with the recession of 1981:07-1982:11. The first three rows of the table presents estimates of the univariate relationship between growth in the recovery and each of the three characteristics of the recession.

From the first row we see that the steepness of the decline in output over the course of the recession has little explanatory power for the rate of growth during the recovery. While the sign of the estimated coefficient is in line with what we would have expected a priori, it is not significantly different from zero at conventional significance levels. The length of the recession has noticeably more explanatory power. The coefficient estimate is significant at the 1% level, and suggests that long recessions tend to be followed by strong recoveries. However, as measured by an adjusted R-squared criterion, it would appear that the depth of a recession tells us the most about the strength of the subsequent recovery. The coefficient estimate indicates that deep recessions tend to be followed by strong recoveries. The next three regressions consider different pairwise combinations of the three basic explanatory variables. We see clearly that neither steepness nor length have any independent explanatory power when considered in conjunction with depth. Finally, the last row considers all three variables together. Obviously this specification suffers from degrees of freedom problems, as well as potential multicollinearity, since the depth variable is simply the product of the steepness and length variables. The correlation matrix at the bottom of the table confirms our suspicions about multicollinearity. What is noteworthy about this regression is that the adjusted R-squared is the same as that for the univariate regression that includes only depth. The coefficient on depth is the only one that is significant at conventional levels, suggesting that only the depth of a recession has any influence on the course of the subsequent recovery.

Table 9 reports results from a similar set of regressions run using detrended output (equation (2) above). The dependant variable is growth in the first twelve months relative to trend. Steepness is measured as the average monthly growth rate (decline) over the course of the recession relative to trend, while depth is measured as the deviation of output at the trough from trend. The measure of length is unchanged. The results here tell much the same story as those in Table 8: the depth of the recession seems to have the most explanatory power for growth in the recovery. The only notable difference with the results in Table 8 is that the adjusted R-squared's are higher than for the corresponding equations in Table 8.

To determine whether the results depended upon having the Great Depression in the sample, we duplicated Tables 8 and 9 except that we excluded the Great Depression from the sample. Table 10 presents the bounce-back regressions for both the basic and detrended specifications. As in the previous analysis, depth of the recession has the most explanatory power for growth in the recovery and is significant in nearly all of the specifications. Therefore, the presence of a bounce-back effect appears to be robust to excluding the Great Depression from the sample.

The results in these tables suggest that we can focus on the depth of the recession alone in trying to explain differences in the pace of recoveries. Table 11 reports results from regressing the rates of growth of various measures of industrial production on depth as measured by the cumulative declines in these measures over the course of recessions. The first four rows use the Federal Reserve's index of industrial production and the major sub-components thereof, namely manufacturing production, durables manufacturing and nondurables manufacturing. The other series are a seasonally adjusted version of the Miron-Romer index of industrial production which spans the period 1884-1940, and an extension of this series constructed by Watson (1994) for the post-World War II period. In each case the depth of the recession is able to explain over half of the variation in growth rates in the early stages of the subsequent recoveries. This bounce-back effect is strongest for the postwar extension of the Miron-Romer series. The results are unchanged if we control for trend variation in the rates of growth of these series. The results are also the same if we use the deviation of output from trend at the trough as the measure of depth to explain growth in output during the recovery.

One possible criticism of these results is their sensitivity to business cycle dates as chosen by the NBER. The results obtained using business cycle dates selected by the Bry and Boschan dating procedure are presented in Table 12. Recall that, except for industrial production, this procedure picks out more peak-to-trough movements in economic activity than are listed in the official NBER chronology. The difference is most notable for the extended Miron-Romer index, for which the Bry and Boschan procedure picks out almost twice as many cycles as there were movements in aggregate activity during the post World War II period. Nonetheless, the parameter estimates are qualitatively the same as those obtained using the NBER dates. The exceptions are nondurable manufacturing, where the bounce-back effect seems to be stronger using the Bry and Boschan dates, and the extended Miron-Romer index, where the effect seems to be weaker.[14]

We have already noted and made use of the concept of business cycle phases that was introduced by Burns and Mitchell (1946). A natural question is whether phase 2 (i.e. the first third of the expansion) corresponds more closely to the notion of a period of recovery than does a fixed twelve month

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[14]Balke and Wynne (1994) extend the analysis of the bounce-back effect to G-7 countries.

horizon after the business cycle trough. Thus, we might expect that growth during phase 2 would be more strongly related to the severity of the prior recession than would growth over a twelve month horizon. In fact it turns out that there is little relationship between growth during phase 2 and any of the measures of recession severity that we look at. One explanation is that because pre-World War I expansions are relatively short (phase 2 averages 6.6 months in the pre World War I sample compared to 16.5 months averaged since World War II) the calendar time (i.e. the first year of expansion) specification is better at picking up the recovery.

5. A Monte Carlo examination of the recovery and bounce-back effects

How special are the recovery and bounce-back effects? Can we reconcile the phenomenon of a recovery with simple time series models? Clearly the concave shape of output is not consistent with two-state Markov models like that of Hamilton (1989). Three-state Markov models similar to the one proposed by Sichel (1992), while capable of capturing the high growth during the recovery phase, cannot capture the general tendency for output growth to fall as the expansion continues (i.e. the slowdown effect). Nor does the three-phase model provide a link between strength of the recovery and the depth of the previous recession.

Linear time series models such as ARIMA models may be able to generate recovery and bounce-back effects; in particular, trend-stationary ARIMA models can conceivably generate both the concave behavior in output and the bounce-back phenomenon. The reason is that peak and trough dates, and hence the phase dates, are not arbitrarily chosen dates; these dates are chosen, subjectively by the NBER or objectively by the Bry-Boschan algorithm, after looking at the data. Because the linear trend-stationary model implies adjustment to deviations from the trend level of output and because recessions may represent significant deviations from trend output, the high growth during the expansion and the bounce-back effect may be the result of trend reversion.

To examine whether the phase and bounce-back results could have been generated by an ARIMA model, we conduct a Monte Carlo experiment in which we estimate an ARIMA model for industrial production and generate pseudo-histories based on the estimated model. The Bry-Boschan algorithm is then used to select peak and trough dates. Based on these dates, we run the phase and bounce-back regressions on the generated data. This experiment is conducted 100 times and the resulting Monte Carlo distribution is compared with the phase and bounce-back regressions based on the true data (and Bry and Boschan dates).

Table 13 presents the phase regression Monte Carlo results for an ARIMA(12,1,0) (difference-stationary) model of post-World War II industrial production and for an ARIMA(13,0,0) with a linear time trend (trend-stationary) model of postwar industrial production.[15] The estimates of the mean and the standard deviation of the Monte Carlo distribution of the phase growth rates are also presented in Table 13. First, it is clear from the table that these linear models can generate plausible cyclical behavior: the phase growth rates show distinct recessions and expansions. In addition, the number of cycles implied by the generated data are not out of line with the

[15] The lags lengths were chosen so that serial correlation in the residuals was eliminated. We also tried more parsimonious models such as an ARIMA(2,1,0) and an ARIMA(2,0,0) with a linear time trend and obtained essentially the same results as those reported in Tables 15 and 16.

actual number of cycles over the relevant sample period.

For both the difference- and trend-stationary models, growth rates in the expansion phases for the Monte Carlo data do not fall in the later expansion phases (phases 3 and 4) nearly as much as in the actual data. Indeed, the actual 1st year of expansion and the phase 2 and 4 growth rates are at least one standard deviation away from the mean of the Monte Carlo distribution. Similarly, the percentage of times that the Monte Carlo replications reject the null hypotheses at p-values less than or equal to the p-value for the actual data are quite small. These results suggest that if either a difference-stationary or trend-stationary ARMA model is the true data generating process for industrial production, then the actual phase regression is far in the tail of the distribution that would be generated by these processes. In other words, it is highly unlikely that ARIMA models for industrial production could have generated the phase behavior present in the actual data.

Table 14 presents the results of the Monte Carlo experiment for the bounce-back regression. Here we regress growth in the first year of the expansion against the depth of the previous recession. To give us more cycles, we estimate ARIMA models for the period 1919-1991. In addition to the estimated ARIMA, we estimated a random walk with drift model for industrial production. As in the phase regressions, the ARIMA data generating processes are unlikely to have generated the actual bounce-back regression. The actual coefficient on the depth of recession variable when the Great Depression is included in the sample is in the 8th, 1st, and 7th percentiles, respectively, of the Monte Carlo distributions. In addition, the actual t-statistic for this coefficient is outside the entire Monte Carlo distribution for both the difference- and trend-stationary models. Even if we exclude the Great Depression, the actual coefficient on the depth of the recession variable is in the 20th, 13th, and 20th percentiles, respectively, and its t-statistic is in the 1st and 8th percentiles. Consequently, it is unlikely that linear difference-stationary or trend-stationary models of industrial production can explain the bounce-back phenomenon. Apparently, the trend reversion in the industrial production series is too weak for the trend-stationary autoregressive model to explain the phase and bounce-back phenomena.

While simple two- and three-state Markov models for the growth rate of output or linear ARIMA models of output cannot explain the phase behavior and the bounce-back phenomenon apparent in industrial production, richer time series models may be able to do so. Nonlinear time-series models, such as threshold autoregressions may better reflect the phase behavior and the bounce-back phenomena present in industrial production than simple linear ARIMA models.[16]

6. Concluding remarks

In this paper, we examined whether the economy grows faster immediately after a recession than in the rest of the expansion and whether the strength of the recovery was related to the depth of the recession. We find that indeed recoveries are characterized by higher than average output growth and that the deeper the recession the faster output grows during the subsequent

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[16] Teräsvirta and Anderson (1991) estimate a smooth transition threshold autoregression to the growth rate of quarterly industrial production. They found that in the low growth regime the autoregression contained explosive roots while in the high growth regime the autoregression has stable roots.

recovery. In addition to finding a recovery effect for output, we found that the shape of the business cycle is characterized by concave expansions--output grows at a slower rate later in the expansion than in the beginning of the expansion--and linear recessions--the rate of contraction is not significantly different over the course of the recession. The high growth during the recovery seems to be driven by inventory investment, consumer durables, and investment in residential structures. The finding that the strength of the recovery depends, in part, on the depth of the recession appears to be quite robust across alternative business cycle dates. In the Monte Carlo analyses, we show that linear time-series models are unlikely to generate significant bounce-back effects and to replicate the actual shape of the business cycle.

The typically concave shape of expansions and the linear shape of recessions suggest an asymmetry over the business cycle that is inconsistent with linear models of the business cycle (see Blatt (1980)). In other work, we show that a standard real business cycle is incapable of capturing the shape of the business cycle (Balke and Wynne (1993)). These models typically generate business cycle shapes with "pointed" peaks rather than the concave expansions found in the data. Nonlinear models of the cycle that utilize the concept of a ceiling on output, such as Friedman's "plucking model" of business cycles (Friedman (1969, 1993)) and Hicks' model of the trade cycle (Hicks (1950)) (which also places a floor on output), may be more consistent with the concavity of output over expansions.

Appendix A

The phase dummies were created as follows.

For monthly data:

(i) phase1 = 1 if t = trough ± 1, 0 otherwise ;

(ii) the length of phase2, phase3, phase4 = integer[(peak - 1 - (trough+1))/3], with the remainder of 1 allocated to phase 3, and the remainder of 2 allocated 1 each to phase2 and phase4;

(iii) phase5 = 1 if t = peak ± 1, 0 otherwise;

(iv) the length of phase6, phase7, phase8 = integer[(trough-1 - (peak+1))/3], with remainder of 1 allocated to phase 7 and a remainder of 2 allocated 1 each to phase 6 and phase8.

For quarterly data:

(i) phase1 = 1 if t = trough, 0 otherwise;

(ii) phase5 = 1 if t = peak, 0 otherwise;

(iii) the length of phase2, phase3, phase4 = integer[(peak-trough)/3] with the remainder allocated as in monthly case. Similarly, the length of phase6, phase7, and phase8 = integer[(trough-peak)/3] with the remainder allocated as above.

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Table 1

Average output growth during different phases of the business cycle

Three Phase

	real GNP	IP
Recession	-2.67 (0.50)	-9.57 (1.38)
1st year of expansion	6.35 (0.98)	12.79 (1.95)
rest of expansion	3.71 (0.33)	4.67 (0.61)
Adj. R^2	0.42	0.27
p-values for H0:		
1st yr ≤ rest of expansion	0.00	0.00

Burns and Mitchell Phases

	real GNP	IP
phase1	-1.16 (1.13)	-1.79 (1.91)
phase2	5.97 (0.82)	10.13 (1.66)
phase3	4.67 (0.45)	5.60 (1.04)
phase4	2.88 (0.37)	4.43 (0.89)
phase5	1.93 (0.65)	-2.06 (1.94)
phase6	-3.04 (0.75)	-8.24 (1.72)
phase7	-3.06 (0.99)	-8.98 (3.04)
phase8	-2.37 (1.42)	-13.33 (4.70)
Adj. R^2	0.44	0.21
p-values for H0:		
ph2 ≤ ph3	0.06	0.01
ph2 ≤ ph4	0.00	0.00
ph3 ≤ ph4	0.00	0.20
ph2 = ph3 = ph4	0.00	0.01
ph6 = ph7 = ph8	0.89	0.58

Notes to Table 1: Dependent variable is period to period+1 growth rate (at annual rates). Sample period for quarterly real GNP is 1947:2-1991:2 and for monthly Federal Reserve Industrial Production (IP) 1947:2 - 1991:6. Standard errors are in parentheses.

Table 2

Phase regressions for alternative industrial production indices

	Fed IP	Miron-Romer	Extended M-R
Recession	-16.99	-12.49	-19.71
	(2.61)	(3.67)	(4.00)
1st year of expansion	17.45	21.69	18.78
	(2.30)	(4.56)	(5.11)
rest of expansion	7.33	10.34	2.92
	(1.19)	(3.75)	(1.16)
Adj. R^2	0.21	0.10	0.07
p-values for Ho:			
1st yr ≤ rest of expansion	0.00	0.03	0.00

	Fed IP	Miron-Romer	Extended M-R
phase1	-4.40	-16.51	-9.80
	(3.45)	(10.49)	(5.70)
phase2	13.14	30.73	11.76
	(1.97)	(6.16)	(3.29)
phase3	9.65	6.32	4.06
	(1.73)	(2.93)	(1.54)
phase4	6.95	11.15	2.80
	(1.46)	(4.91)	(2.22)
phase5	0.75	14.60	-2.31
	(2.58)	(5.34)	(4.03)
phase6	-15.05	-18.07	-15.76
	(3.50)	(5.87)	(3.44)
phase7	-18.84	-13.44	-18.42
	(5.89)	(6.44)	(5.53)
phase8	-17.28	-7.59	-19.37
	(4.20)	(9.16)	(5.20)
Adj. R^2	0.16	0.13	0.03
p-values for Ho:			
ph2 ≤ ph3	0.09	0.00	0.03
ph2 ≤ ph4	0.00	0.01	0.01
ph3 ≤ ph4	0.07	0.79	0.32
ph2=ph3=ph4	0.03	0.00	0.07
ph6=ph7=ph8	0.80	0.65	0.75

Notes to Table 2: Dependent variable is period to period+1 growth rate (at annual rate). Sample period for monthly Federal Reserve Industrial Production Index (FED IP) is 1919:2 to 1990:6, for monthly Miron-Romer series 1884:2 to 1940:12, and for monthly extended Miron-Romer series 1947:2 to 1990:6. Standard errors are in parentheses.

Table 3

Alternative business cycle chronologies

NBER Dates		Bry-Boschan Dates from M-R IP		Bry-Boschan Dates from Fed IP	
peak	trough	peak	trough	peak	trough
	1885:5				
1887:3	1888:4	1887:3	1887:8		
1890:7	1891:5	1890:9	1891:6		
1893:1	1894:6	1892:6	1893:12		
1895:12	1897:6	1895:11	1896:9		
		1897:7	1898:7		
1899:6	1900:12	1899:9	1900:12		
1902:9	1904:8	1901:9	1902:7		
		1905:10	1906:6		
1907:4	1908:6	1907:9	1908:5		
1910:1	1912:1	1910:2	1910:12		
1913:1	1914:12	1913:1	1915:1		
1918:8	1919:3	1917:8	1919:2		
1920:1	1921:7	1920:3	1921:7	1920:2	1921:4
1923:5	1924:7	1923:6	1923:11	1923:5	1924:7
1926:10	1927:11	1926:3	1927:3	1927:3	1927:12
1929:8	1933:3	1929:6	1933:4	1929:7	1932:7
		1933:11	1934:12		
1937:5	1938:6	1937:2	1938:8	1937:5	1938:6
1945:2	1945:10			1944:4	1946:2
1948:11	1949:10	1948:10	1949:10	1948:7	1949:10
		1951:6	1952:7		
1953:7	1954:5	1953:8	1954:4	1953:7	1954:4
1957:8	1958:4	1955:12	1958:4	1957:3	1958:4
		1959:5	1959:10		
1960:4	1961:2			1960:1	1961:2
		1961:12	1962:6		
		1966:10	1967:6		
1969:12	1970:11	1969:11	1971:8	1969:10	1970:11
1973:11	1975:3	1973:12	1975:5	1973:11	1975:3
1980:1	1980:7	1978:12	1980:7		
1981:7	1982:11	1981:2	1982:12	1981:7	1982:12
		1984:5	1986:9		
		1985:12	1986:9		
		1989:4	1989:12		
1990:7		1990:8		1990:9	

Notes to Table 3: For Fed IP, sample period for Bry-Boschan algorithm is 1919:1 to 1991:6. For Miron-Romer (M-R) Dates, the Bry-Boschan algorithm uses the Miron-Romer IP series for 1884:1 to 1940:12 and the extended Miron-Romer series of Watson (1992) for 1947:1 to 1991:6.

Table 4
Phase regressions for Bry-Boschan dates

Three Phase Regression	Fed IP 1947:2-1991:6	Fed IP 1919:2-1991:6	Miron-Romer	Extended M-R
Recession	-9.58	-17.89	-26.30	-17.83
	(1.19)	(1.19)	(3.49)	(3.63)
1st year of expansion	13.68	18.93	28.98	19.67
	(2.02)	(2.82)	(4.73)	(4.05)
rest of expansion	4.87	7.50	15.52	6.45
	(0.64)	(1.34)	(3.07)	(3.63)
Adj. R^2	0.27	0.23	0.30	0.12
p-values for H0: 1st yr ≤ rest of expansion	0.00	0.00	0.01	0.00

Burns and Mitchell Phase Regression	Fed IP 1947:2-1991:6	Fed IP 1919:2-1991:6	Miron-Romer	Extended M-R
phase1	-2.37	-3.20	-15.41	-1.22
	(1.82)	(2.27)	(4.56)	(7.62)
phase2	9.72	12.66	26.43	13.54
	(1.70)	(2.04)	(6.16)	(3.38)
phase3	6.11	9.20	15.86	7.26
	(1.03)	(1.67)	(5.46)	(2.52)
phase4	3.26	7.72	25.59	8.32
	(1.27)	(2.17)	(4.26)	(2.12)
phase5	3.43	4.31	10.79	1.96
	(3.85)	(2.99)	(2.53)	(1.61)
phase6	-6.88	-11.10	-27.67	-9.39
	(1.65)	(3.59)	(3.81)	(5.59)
phase7	-7.65	-16.32	-11.69	-8.77
	(2.77)	(5.67)	(7.54)	(2.80)
phase8	-12.82	-26.46	-39.23	-21.13
	(4.36)	(4.83)	(7.01)	(6.66)
Adj. R^2	0.19	0.18	0.27	0.04

Table 4 (continued)

p-values for Extended Ho:	Fed IP 1947:2-1991:6	Fed IP 1919:2-1991:6	Miron-Romer	M-R
ph2 ≤ ph3	0.03	0.10	0.09	0.05
ph2 ≤ ph4	0.00	0.05	0.45	0.10
ph3 ≤ ph4	0.06	0.27	0.96	0.61
ph2=ph3=ph4	0.02	0.25	0.18	0.23
ph6=ph7=ph8	0.53	0.04	0.02	0.11

Notes to Table 4: Standard errors are in parentheses.

Table 5
Phase regressions for components of real GNP (1947:2-1991:2)

Three Phase Regression	Consumption Total	Consumption Durable	Consumption ND & ser	Investment Total	Investment Res Struct	Investment PDE	Investment Non Res Struct	Investment Inventory
Recession	0.64	-3.80	1.25	-19.78	-6.74	-12.88	-6.28	-10.51
	(0.42)	(2.69)	(0.29)	(3.26)	(5.42)	(2.46)	(2.08)	(2.07)
1st year of expansion	4.80	14.04	3.63	25.32	19.67	10.77	2.40	11.45
	(0.50)	(1.86)	(0.40)	(4.01)	(3.52)	(2.46)	(2.65)	(2.21)
rest of expansion	3.45	4.21	3.33	3.05	0.16	6.61	3.85	-0.41
	(0.28)	(1.19)	(0.23)	(1.64)	(2.06)	(1.22)	(1.29)	(0.90)
Adj. R^2	0.16	0.10	0.12	0.36	0.13	0.27	0.11	0.16
p-values for H0: 1st yr ≤ rest of expansion	0.01	0.00	0.26	0.00	0.00	0.07	0.69	0.00

Burns and Mitchell Phase Regression	Consumption Total	Consumption Durable	Consumption ND & ser	Investment Total	Investment Res Struct	Investment PDE	Investment Non Res Struct	Investment Inventory
phase1	2.84	-0.34	3.12	-19.32	17.13	-11.69	-7.79	-18.88
	(0.62)	(4.99)	(0.26)	(9.29)	(8.60)	(3.54)	(2.55)	(7.66)
phase2	4.72	12.41	3.73	20.11	17.82	10.20	3.38	7.38
	(0.32)	(1.56)	(0.24)	(4.33)	(3.04)	(2.08)	(1.87)	(2.60)
phase3	4.01	5.95	3.74	5.75	2.56	8.83	3.22	1.48
	(0.49)	(2.28)	(0.38)	(2.80)	(4.30)	(1.86)	(2.55)	(1.45)
phase4	2.91	2.75	2.94	1.75	-0.19	3.86	4.87	-1.86
	(0.44)	(1.54)	(0.36)	(1.64)	(2.67)	(1.49)	(1.68)	(1.33)
phase5	2.04	-0.21	2.34	-3.62	-22.43	5.64	2.81	2.19
	(0.66)	(2.46)	(0.60)	(5.43)	(4.32)	(2.32)	(1.62)	(4.34)
phase6	-1.01	-8.42	0.01	-24.96	-18.53	-7.52	-5.11	-15.54
	(0.80)	(2.64)	(0.76)	(4.18)	(9.26)	(4.37)	(2.49)	(3.55)
phase7	0.88	3.67	0.69	-25.22	-22.56	-14.06	-7.79	-7.53
	(2.77)	(5.67)	(7.54)	(2.80)	(9.26)	(4.83)	(2.64)	(2.60)
phase8	-0.41	-10.54	0.92	-9.65	-5.98	-18.38	-4.23	0.95
	(1.02)	(5.73)	(0.77)	(7.32)	(9.10)	(4.58)	(3.65)	(4.56)
Adj. R^2	0.21	0.10	0.18	0.32	0.26	0.27	0.10	0.14

Table 5 (continued)

	Consumption			Investment				
p-values for Ho: Inventory	Total	Durable	ND & ser	Total	Res Struct	PDE	Non Res Struct	
ph2 ≤ ph3	0.12	0.01	0.50	0.01	0.00	0.33	0.48	0.02
ph2 ≤ ph4	0.00	0.00	0.04	0.00	0.00	0.01	0.72	0.00
ph3 ≤ ph4	0.07	0.14	0.08	0.09	0.31	0.01	0.71	0.07
ph2=ph3=ph4	0.01	0.00	0.18	0.00	0.00	0.01	0.78	0.01
ph6=ph7=ph8	0.44	0.18	0.65	0.25	0.34	0.13	0.59	0.05

Notes to Table 5: All data are quarterly. Dependent variable is period to period+1 growth rate (at annual rates) except inventory investment which is change in the level. Durables consumption includes dummy variables for 1950:3-1951:2. Standard errors are in parentheses.

Table 5 (continued)

Three Phase Regression	Government	Exports	Imports	Final Sales
Recession	1.06	-2.83	-4.47	-0.59
	(1.65)	(3.07)	(2.35)	(0.43)
1st year of expansion	0.83	2.06	12.99	4.12
	(1.41)	(1.41)	(2.36)	(0.60)
rest of expansion	4.88	7.57	7.68	3.85
	(1.53)	(2.00)	(0.90)	(0.34)
Adj. R^2	0.03	0.05	0.11	0.25
p-values for H0: 1st yr ≤ rest of expansion	0.99	0.98	0.02	0.33

Burns and Mitchell Phase Regression	Government	Exports	Imports	Final Sales
phase1	0.51	-4.94	-2.68	1.57
	(2.84)	(7.91)	(7.80)	(0.84)
phase2	2.22	4.77	12.20	4.46
	(1.22)	(1.06)	(2.41)	(0.39)
phase3	5.93	8.07	8.16	4.63
	(2.86)	(2.13)	(1.09)	(0.56)
phase4	3.35	6.47	8.03	3.07
	(1.37)	(3.20)	(1.65)	(0.34)
phase5	5.03	3.54	1.66	1.92
	(2.03)	(3.57)	(2.56)	(0.56)
phase6	1.79	7.94	-6.96	-0.39
	(1.09)	(6.13)	(3.84)	(0.46)
phase7	2.14	-2.70	-2.97	-1.37
	(2.32)	(2.65)	(5.18)	(1.20)
phase8	-0.07	-11.37	-5.48	-2.44
	(3.59)	(4.26)	(3.46)	(1.38)
Adj. R^2	0.00	0.04	0.09	0.32

Table 5 (continued)

p-values for Ho:	Government	Exports	Imports	Final Sales
ph2 ≤ ph3	0.93	0.92	0.08	0.62
ph2 ≤ ph4	0.73	0.69	0.08	0.00
ph3 ≤ ph4	0.19	0.31	0.48	0.00
ph2=ph3=ph4	0.32	0.37	0.31	0.01
ph6=ph7=ph8	0.87	0.01	0.88	0.25

Notes to Table 5: All data are quarterly. Dependent variable is period to period+1 growth rate (at an annual rate). Standard errors are in parentheses.

Table 6
Phase regressions for Output, Productivity, Hours, and Real Compensation in Manufacturing (1947:2-1991:2)

Three Phase Regression	Output	Productivity	Hours	Real compensation
Recession	-10.15	0.05	-10.21	2.13
	(1.23)	(0.84)	(2.50)	(0.46)
1st year of expansion	11.43	5.42	6.00	1.57
	(1.98)	(0.68)	(1.51)	(0.80)
rest of expansion	4.05	2.42	1.62	1.62
	(0.75)	(0.48)	(0.56)	(0.43)
Adj. R^2	0.45	0.12	0.50	-0.01
p-values for H0: 1st yr ≤ rest of expansion	0.00	0.00	0.00	0.52

Burns and Mitchell Phase Regression compensation	Output	Productivity	Hours	Real
phase1	-9.27	0.95	-10.23	2.23
	(3.04)	(1.28)	(2.50)	(0.70)
phase2	10.31	5.38	4.92	2.01
	(1.69)	(0.68)	(1.33)	(0.66)
phase3	5.66	2.56	3.09	1.53
	(0.88)	(0.55)	(0.81)	(0.45)
phase4	3.66	2.33	1.32	1.66
	(1.13)	(0.67)	(0.76)	(0.67)
phase5	-2.03	0.41	-2.45	0.86
	(1.55)	(1.50)	(1.16)	(1.49)
phase6	-11.72	-2.66	-9.06	1.59
	(1.82)	(2.15)	(1.30)	(1.02)
phase7	-8.99	2.11	-11.10	3.55
	(3.30)	(1.71)	(2.37)	(0.81)
phase8	-10.77	0.30	-10.43	1.15
	(3.16)	(1.72)	(1.78)	(0.81)
Adj. R^2	0.45	0.15	0.50	-0.02

Table 6 (continued)

p-values for Ho:	Output	Productivity	Hours	Real compensation
ph2 ≤ ph3	0.01	0.00	0.12	0.26
ph2 ≤ ph4	0.00	0.00	0.01	0.35
ph3 ≤ ph4	0.07	0.38	0.06	0.58
ph2=ph3=ph4	0.01	0.00	0.06	0.82
ph6=ph7=ph8	0.82	0.28	0.49	0.12

Notes to Table 6: All data are quarterly. Dependent variable is period to period+1 growth rate (at an annual rate). Standard errors are in parentheses.

Table 7
Phase regressions for Employment, Prices, Money and Interest Rates (1947:2-1991:2)

Three Phase Regression	Nonag Employ.	Fix Wgt Deflator	CPI	Money Base	M2	M2 velocity	Stock prices	10yr-3mth spread
Recession	-2.84	5.36	4.55	4.70	5.40	-3.71	-3.57	0.90
	(0.67)	(1.02)	(1.13)	(1.13)	(0.92)	(0.87)	(5.47)	(0.26)
1st year of expansion	3.34	4.93	3.31	4.86	7.71	2.99	20.22	1.43
	(0.21)	(1.02)	(0.96)	(1.07)	(1.17)	(1.56)	(2.46)	(0.39)
rest of expansion	3.03	3.59	4.28	5.12	6.20	1.52	5.04	0.95
	(0.54)	(0.58)	(0.61)	(0.62)	(0.60)	(0.60)	(2.43)	(0.24)
Adj. R^2	0.31	0.03	0.01	-0.00	0.03	0.17	0.02	0.02
p-values for H0: 1st yr ≤ rest of expansion	0.33	0.11	0.84	0.59	0.09	0.17	0.00	0.12

Burns and Mitchell Phase Regression	Nonag Employ.	Fix Wgt Deflator	CPI	Money Base	M2	M2 velocity	Stock prices	10yr-3mth spread
phase1	-2.27	5.21	2.83	4.72	7.76	-4.75	46.30	1.89
	(0.58)	(1.33)	(0.89)	(1.53)	(1.45)	(0.76)	(9.03)	(0.14)
phase2	3.57	3.13	3.15	4.93	8.32	1.44	15.03	1.72
	(0.54)	(0.77)	(0.75)	(0.93)	(0.95)	(1.49)	(3.35)	(0.24)
phase3	3.58	3.82	3.65	5.78	6.72	1.74	4.21	1.20
	(0.37)	(0.65)	(0.64)	(0.73)	(0.75)	(0.80)	(5.37)	(0.33)
phase4	2.71	4.68	5.21	4.54	5.31	2.42	5.75	0.30
	(0.25)	(0.80)	(0.86)	(0.86)	(0.73)	(0.80)	(2.42)	(0.21)
phase5	0.44	3.54	5.82	3.40	4.46	1.93	-4.07	-0.20
	(0.53)	(1.84)	(1.96)	(1.42)	(1.09)	(1.02)	(5.14)	(0.39)
phase6	-1.35	6.02	5.62	4.45	4.46	-3.92	-17.11	0.39
	(0.97)	(1.41)	(1.76)	(1.35)	(1.46)	(1.05)	(8.48)	(0.43)
phase7	-2.70	6.49	4.73	4.53	3.75	-2.59	-23.43	0.54
	(0.81)	(1.94)	(1.41)	(1.42)	(0.95)	(2.11)	(9.59)	(0.28)
phase8	-3.90	3.55	4.00	5.37	6.71	-3.45	0.20	1.51
	(0.73)	(1.50)	(1.68)	(1.52)	(1.19)	(1.66)	(10.78)	(0.41)
Adj. R^2	0.31	0.01	0.03	0.00	0.10	0.14	0.07	0.29

Table 7 (continued)

p-values for Ho:	Nonag Employ.	Fix Wgt Deflator	CPI	Money Base	M2	M2 velocity	Stock prices	10yr-3mth spread
ph2 ≤ ph3	0.51	0.79	0.72	0.80	0.04	0.59	0.04	0.06
ph2 ≤ ph4	0.08	0.93	0.97	0.37	0.00	0.72	0.01	0.00
ph3 ≤ ph4	0.02	0.81	0.97	0.08	0.06	0.74	0.60	0.00
ph2=ph3=ph4	0.07	0.35	0.12	0.34	0.03	0.79	0.05	0.00
ph6=ph7=ph8	0.09	0.11	0.50	0.83	0.04	0.78	0.03	0.01

Notes to Table 7: All data are monthly except the fixed weight GNP deflator. All variable are in annual growth rates except interest rate spread. Stock prices includes a dummy variable for 1987:10. Sample period for nonagricultural employment is 1948:2-1991:2 while for interest rate spread the sample period is 1953:2-1991:2. Standard errors are in parentheses.

Table 8
Estimates of $g_i(12) = \alpha_0 + \alpha_1 s_i + \alpha_2(T_i - P_i) + \alpha_3 d_i$
Industrial production; NBER business cycle dates

α_0	α_1	α_2	α_3	$\bar{R}^2$	se
1.091*** (0.322)	-0.231 (0.181)			0.05	0.711
0.614*** (0.272)		0.057*** (0.016)		0.46	0.535
0.801*** (0.173)			-0.031*** (0.006)	0.64	0.440
0.299 (0.306)	-0.224 (0.125)	0.057*** (0.015)		0.55	0.491
0.906*** (0.203)	0.138 (0.138)		-0.035*** (0.008)	0.64	0.440
0.716** (0.235)		0.013 (0.023)	-0.026** (0.011)	0.61	0.453
1.702** (0.752)	0.558 (0.406)	-0.073 (0.066)	-0.076* (0.038)	0.64	0.436

Notes to Table 8. The basic series is the Federal Reserve's Index of industrial production (seasonally adjusted). There are 14 observations in each regression. The sample period starts with the recession of 1920:01-1921:04 and ends with the recession of 1981:07-1982:11. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level. Standard errors are in parentheses.

Correlation matrix

	s	(T-P)	d
s	1.00	-0.04	0.61
(T-P)		1.00	-0.80
d			1.00

Table 9

Estimates of $g_i(12) - r_i = \alpha_0 + \alpha_1(s_i - r_i) + \alpha_2(T_i - P_i) + \alpha_3(s_i - r_i)(T_i - P_i)$
Industrial production; NBER business cycle dates

α_0	α_1	α_2	α_3	$\bar{R}^2$	se
0.616	-0.320			0.13	0.691
(0.367)	(0.187)				
0.308		0.061***		0.50	0.522
(0.266)		(0.016)			
0.381**			-0.033***	0.73	0.382
(0.163)			(0.005)		
-0.252	-0.326**	0.061***		0.70	0.406
(0.280)	(0.110)	(0.013)			
0.427*	0.046		-0.034***	0.71	0.396
(0.214)	(0.129)		(0.007)		
0.337		0.008	-0.030***	0.71	0.396
(0.202)		(0.021)	(0.009)		
0.276	-0.034	0.013	-0.028	0.69	0.415
(0.769)	(0.410)	(0.065)	(0.036)		

Notes to Table 9. The basic series is the Federal Reserve's Index of industrial production (seasonally adjusted). There are 14 observations in each regression. The sample period starts with the recession of 1920:01-1921:04 and ends with the recession of 1981:07-1982:11. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level. Standard errors are in parentheses.

Correlation matrix

	s	(T-P)	d
s	1.00	-0.02	0.59
(T-P)		1.00	-0.81
d			1.00

Table 10
Estimates of $g_i(12) = \alpha_0 + \alpha_1 s_i + \alpha_2(T_i - P_i) + \alpha_3 d_i$
Excluding the Great Depression
Industrial production; NBER business cycle dates

α_0	α_1	α_2	α_3	$\bar{R}^2$	se
1.001***	-0.200			0.08	0.542
(0.246)	(0.138)				
0.668		0.053		0.03	0.558
(0.559)		(0.045)			
0.828***			-0.029**	0.35	0.458
(0.213)			(0.011)		
0.233	-0.227	0.062		0.17	0.515
(0.574)	(0.132)	(0.042)			
0.871***	0.286		-0.051**	0.38	0.446
(0.210)	(0.225)		(0.020)		
0.585		0.023	-0.026**	0.30	0.472
(0.474)		(0.040)	(0.011)		
1.550*	0.590	-0.061	-0.080*	0.36	0.452
(0.832)	(0.426)	(0.072)	(0.040)		

Estimates of $g_i(12) - r_i = \alpha_0 + \alpha_1(s_i - r_i) + \alpha_2(T_i - P_i) + \alpha_3(s_i - r_i)(T_i - P_i)$
Excluding the Great Depression
Industrial production; NBER business cycle dates

α_0	α_1	α_2	α_3	$\bar{R}^2$	se
0.490	-0.310**			0.34	0.426
(0.228)	(0.115)				
0.617		0.033		-0.03	0.534
(0.535)		(0.043)			
0.460**			-0.028***	0.45	0.390
(0.200)			(0.008)		
-0.013	-0.320**	0.041		0.37	0.418
(0.474)	(0.113)	(0.034)			
0.440*	-0.059		-0.024	0.40	0.399
(0.221)	(0.206)		(0.017)		
0.559		-0.010	-0.029**	0.40	0.407
(0.408)		(0.036)	(0.010)		
0.496	-0.035	-0.049	-0.026	0.33	0.429
(0.875)	(0.424)	(0.074)	(0.037)		

Notes to Table 10. The basic series is the Federal Reserve's Index of industrial production (seasonally adjusted). There are 14 observations in each regression. The sample period starts with the recession of 1920:01-1921:04 and ends with the recession of 1981:07-1982:11. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level. Standard errors are in parentheses.

Table 11
Estimates of $g_i(12) = \alpha_0 + \alpha_1 d_i$
NBER business cycle dates

Series	α_0	α_1	$\bar{R}^2$	se	N	T
IP	0.801***	-0.031***	0.64	0.440	14	1920:01-1921:07
	(0.173)	(0.006)				1981:07-1982:11
MFG	0.878**	-0.029***	0.59	0.506	14	"
	(0.197)	(0.006)				
DUR	0.840**	-0.039***	0.72	0.946	14	"
	(0.352)	(0.007)				
NDUR	0.729***	-0.027***	0.60	0.229	14	"
	(0.081)	(0.006)				
MRSA	0.831**	-0.051***	0.63	0.941	15	1887:03-1888:04
	(0.317)	(0.010)				1937:05-1938:06
XMRSA	-0.780	-0.121***	0.84	0.529	8	1948:11-1949:10
	(0.427)	(0.020)				1981:07-1982:11

Notes to Table 11. The basic series are the Federal Reserve's index of industrial production (IP), and its sub-components, manufacturing production (MFG), durables manufacturing (DUR), and nondurables manufacturing (NDUR), all seasonally adjusted. MRSA is the Miron-Romer(1990) industrial production index, seasonally adjusted. XMRSA is the extended Miron-Romer index for the post World War II period constructed by Watson (1992). N denotes the number of observations in each series. T gives the dates of the first and last recessions covered by each series. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level. Standard errors are in parentheses.

Table 12
Estimates of $g_i(12) = \alpha_0 + \alpha_1 d_i$
Bry-Boschan dates

Series	α_0	α_1	$\bar{R}^2$		N	T
IP	0.720***	-0.037***	0.73	0.462	13	1920:02-1921:04
	(0.196)	(0.006)				1981:07-1982:12
MFG	0.734***	-0.036***	0.76	0.453	15	1920:02-1921:04
	(0.169)	(0.005)				1981:07-1982:12
DUR	0.986***	-0.036***	0.73	0.866	15	1923:05-1924:07
	(0.304)	(0.006)				1981:07-1982:12
NDUR	0.485***	-0.054***	0.84	0.323	16	1920:01-1920:12
	(0.114)	(0.006)				1981:07-1982:07
MRSA	0.839**	-0.043***	0.51	0.887	18	1887:03-1887:08
	(0.378)	(0.010)				1937:02-1939:08
XMRSA	-0.043	-0.080***	0.75	0.571	14	1948:10-1949:10
	(0.291)	(0.013)				1989:04-1989:12

Notes to Table 12. The basic series are the Federal Reserve's index of industrial production (IP), and its sub-components, manufacturing production (MFG), durables manufacturing (DUR), and nondurables manufacturing (NDUR), all seasonally adjusted. MRSA is the Miron-Romer(1990) industrial production index, seasonally adjusted. XMRSA is the extended Miron-Romer index for the post World War II period constructed by Watson (1992). N denotes the number of observations in each series. T gives the dates of the first and last recessions covered by each series. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level. Standard errors are in parentheses.

Table 13

Phase regressions for data generated by ARIMA Models estimated to Fed IP Index, 1947:1-1991:6

Three Phase Regression

	Actual	Monte Carlo Avg and (st dev) ARIMA (12,1,0)	Monte Carlo Avg and (st dev) ARIMA (13,0,0)
Recession	-9.58	-7.55	-7.55
		(1.08)	(1.11)
1st year of expansion	13.68	9.29	9.40
		(1.60)	(1.46)
rest of expansion	4.87	7.36	7.42
		(0.88)	(0.94)

percent of replications with p-value < actual

Ho:	Actual p-value	ARIMA (12,1,0)	ARIMA (13,0,0)
1st yr $\le$ rest of expansion	0.00	0.01	0.01

	Actual	ARIMA (12,1,0)	ARIMA (13,0,0)
number of cycles	8	11.1	10.8
		(3.5)	(3.4)

Burns and Mitchell Phases

	Actual	Monte Carlo Avg and (st dev) ARIMA (12,1,0)	Monte Carlo Avg and (st dev) (13,0,0)
phase1	-2.37	-3.04	-3.11
		(1.32)	(1.69)
phase2	9.72	8.14	8.20
		(1.53)	(1.69)
phase3	6.11	7.41	7.57
		(1.61)	(1.67)
phase4	3.26	8.20	8.16
		(1.63)	(1.71)
phase5	3.43	3.28	3.30
		(1.74)	(1.55)
phase6	-6.88	-7.80	-7.95
		(2.85)	(2.05)
phase7	-7.65	-6.12	-5.86
		(1.94)	(1.85)
phase8	-12.82	-6.77	-6.88
		(2.61)	(2.48)

percent of replications with p-values < actual

Ho:	Actual p-value	ARIMA (12,1,0)	ARIMA (13,0,0)
ph2 $\le$ ph3	0.03	0.12	0.10
ph2 $\le$ ph4	0.00	0.00	0.01
ph3 $\le$ ph4	0.06	0.02	0.07
ph2=ph3=ph4	0.02	0.07	0.07
ph6=ph7=ph8	0.53	0.60	0.71

Notes to Table 13: 100 replications. Peak and trough dates were selected by Bry-Boschan algorithm.

Table 14

Bounce-back regressions for data generated by ARIMA models estimated to Fed IP Index, 1919:1-1991:6

			Monte Carlo Average and (standard deviation)		
	Actual with Depression	Actual without Depression	ARIMA (0,1,0)	ARIMA (12,1,0)	ARIMA (13,0,0)
Deepness coefficient	-0.0369	-0.0226	-0.0066 (0.0212)	-0.0051 (0.0143)	-0.0105 (0.0169)
Deepness t-stat	-5.80	-2.58	-0.25 (0.97)	-0.32 (0.92)	-0.70 (1.14)
Number of cycles in sample	13	12	16.6 (5.8)	19.0 (6.1)	18.7 (4.5)
Percent of Monte Carlo Replications with:					
Deepness coefficient < Actual (w/ Depression)			0.08	0.01	0.07
Deepness t-stat < Actual (w/ Depression)			0.00	0.00	0.00
Deepness coefficient < Actual (wo/ Depression)			0.20	0.13	0.20
Deepness t-stat < Actual (wo/ Depression)			0.01	0.01	0.08

Notes to Table 14. 100 replications. Peak and trough dates were selected by Bry-Boschan algorithm.

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