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THE SEASONAL CYCLE AND THE BUSINESS CYCLE

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ABSTRACT

Almost all recent research on macroeconomic fluctuations has worked with seasonally adjusted or annual data. This paper takes a different approach by treating seasonal fluctuations as worthy of study in their own right. We document the quantitative importance of seasonal fluctuations, and we present estimates of the seasonal patterns in a set of standard macroeconomic variables. Our results show that seasonal fluctuations are an important source of variation in all macroeconomic quantity variables but small or entirely absent in both real and nominal price variables. The timing of the seasonal fluctuations consists of increases in the second and fourth quarter, a large decrease in the first quarter, and a mild decrease in the third quarter.

The paper demonstrates that, with respect to each of several major stylized facts about business cycles, the seasonal cycle displays the same characteristics as the business cycle, in some cases even more dramatically than the business cycle. That is, we find that at seasonal frequencies as well as at business cycle frequencies, output movements across broadly defined sectors move together, the timing of production and sales coincide closely, labor productivity is procyclical, nominal money and real output are highly correlated, and prices vary less than quantities. There is a "seasonal business cycle" in the United States economy, and its characteristics mirror closely those of the conventional business cycle.

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I. Introduction

Almost all recent research on macroeconomic fluctuations has worked with seasonally adjusted or annual data. The usual attitude toward seasonal fluctuations is typified by Sims (1974), who refers to the seasonal components of economic time series as "errors in variables" and analyzes methods for treating series "contaminated by seasonal noise." Perhaps underlying this view is the notion that seasonal fluctuations are generated by a fundamentally different model than conventional business cycle fluctuations. One immediate distinction, of course, is between the anticipated nature of seasonal fluctuations and the unanticipated and irregular nature of business cycle fluctuations. Further, many economists would argue that seasonal fluctuations are entirely natural or even desirable while business cycle fluctuations entail large welfare losses.

This paper takes a different approach from previous research by treating seasonal fluctuations as worthy of study in their own right. Instead of taking it for granted that seasonal fluctuations follow a different model from business cycle fluctuations, we consider the extent to which the two types of fluctuations display similarities. Our paper represents a return to an older tradition of NBER analysis of fluctuations, exemplified by Simon Kuznets (1933), in which fluctuations at both seasonal and business cycle frequencies were regarded as important topics of investigation.[1]

In Section III below, we document the quantitative importance of seasonal fluctuations, and we present estimates of the seasonal patterns in a set of standard macroeconomic variables. Our results show that seasonal fluctuations are an important source of variation in all macroeconomic quantity variables, including consumption, investment, government purchases, employment, and the money stock. On the other hand, seasonal fluctuations are small or entirely absent in both real and nominal price variables. The timing of the seasonal fluctuations in economic activity consists of increases in the second and fourth quarter, a large decrease in the first quarter, and a mild decrease in the third quarter. In the fourth quarter boom, output is on average 8.08% higher than in the "recession" that occurs every winter.

We demonstrate in Section IV that, with respect to each of several major stylized facts about business cycles, the seasonal cycle displays the same characteristics as the business cycle, in some cases even more dramatically than the business cycle. That is, we find that at seasonal frequencies as well as at business cycle frequencies, output movements across broadly defined sectors move together, the timing of production and sales coincide closely, labor productivity is procyclical,

[1] Kuznets (1933) carries out a careful study of the seasonality of selected United States industries. Woytinsky (1939) and Bursk (1931) study the seasonality of employment fluctuations, while Kemmerer (1910) and Macaulay (1938) analyze the seasonality of interest rates.

nominal money and real output are highly correlated, and prices vary less than quantities. There is a "seasonal business cycle" in the United States economy, and its characteristics mirror closely those of the conventional business cycle.

The remainder of the paper is organized as follows. Section II outlines a simple estimation strategy for presenting facts about the seasonal cycle and comparing the seasonal cycle to the business cycle. Section III uses this strategy to show that the seasonal cycle is a quantitatively important feature of the data and to document the seasonal patterns in major macroeconomic variables. In Section IV we compare the seasonal cycle to the business cycle and show that the seasonal cycle in the United States economy displays the important qualitative features of the business cycle. Section V concludes the paper.

II. Comparing the Seasonal Cycle and the Business Cycle

In this section we outline our statistical approach to quantifying and presenting seasonal patterns in quarterly macroeconomic time series. We follow Hylleberg (1986,Ch.2) and especially Pierce (1978) in considering a model that includes both deterministic and stochastic seasonal components. In contrast to the standard literature, however, we focus mainly on the deterministic seasonals – those which are representable by seasonal dummy variables.

Our emphasis on deterministic seasonality reflects three observations which, although logically distinct, cohere well. First, the empirical results presented in Section III suggest that deterministic seasonals go a long way toward accounting for the variation in the data, while models of stationary indeterministic seasonality play a secondary role. Second, as noted below, if deterministic seasonals are present but not accounted for, inferences about seasonal comovements based on coherences are essentially incorrect. Finally, *a priori* reasoning about the economics of seasonality suggests the inadequacy of purely indeterministic models in capturing the key characteristics of seasonals in real world data. A stationary indeterministic model implies that the unconditional first quarter mean of a series is equal to the unconditional fourth quarter mean. This in turn implies that the long-run forecast of a series is independent of the quarter being forecast. Of course, a nonstationary indeterministic model - one with a unit root at the fourth lag - would allow seasonality to enter the long-run forecasts (Bell (1987)). However, that approach would still fail to use the information that Christmas falls in the same quarter every year.

Let X_t be a times series of interest. We wish to estimate the seasonal variation in the non-trend component of X_t. In order to insure that our conclusions about seasonality are not sensitive to the choice of detrending technique, we employ two alternative definitions of trend and estimate the seasonal variation in both detrended series. The first representation of trend that we consider is that of a unit root in the ARIMA representation of the indeterministic component of $\ln X_t$. Recent work by Nelson and Plosser (1982), Campbell and Mankiw (1986), and others[2] indicates that this specification may be more consistent with observed data than the specification that $\ln X_t$ is stationary around a deterministic trend.[3] The second model that we employ is the spline function proposed by Hodrick and Prescott (1980).[4] Let τ_t be the trend component of $\ln X_t$. The τ_t are chosen to minimize

$$\sum_{t=1}^{T}(\ln X_t - \tau_t)^2 + 1600\sum_{t=2}^{T-1}((\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1}))^2$$

and the detrended variable is defined to be the difference between $\ln X_t$ and τ_t. This model allows the trend component of $\ln X_t$ to change slowly over time. Note that the interpretation of the detrended series is different for the two models. The first produces log growth rates, the second percentage deviations from trend.[5]

Now let x_t be the detrended series produced by one of the two procedures described above. We assume that x_t can be approximately described by the following model:

$$x_t = \sum_{s=1}^{4}\xi_s d_t^s + \beta(L)\epsilon_t \qquad (1)$$

where $\beta(L)$ is a polynomial in the lag operator, d_t^s is a seasonal dummy for quarter s, ξ_s is a coefficient, and the polynomial $\beta(L)$ satisfies $\sum_{i=0}^{\infty}\beta_i^2 < \infty$. Thus, we model x_t as the sum of deterministic seasonal dummies and a stationary moving average process. This specification allows for both deterministic and stochastic seasonality in x_t. If the seasonal dummy coefficients are not all identical, then the series displays deterministic seasonality. If the polynomial $\beta(L)$ implies a quantitatively important *4th* order autocorrelation in the non-seasonal dummy component of

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[2] Clark (1986), Cochrane (1986), Evans (1986), Stock and Watson (1986), and Watson (1986) also find that one cannot reject the hypothesis of a unit root in the univariate ARIMA representation of real, seasonally adjusted GNP. They reach a range of conclusions, however, about the quantitative importance of the permanent component.

[3] The fact that one cannot reject the hypothesis of a unit root does not imply that one is present, since tests for unit roots tend to have limited power (Shiller and Perron (1985)). We also note that existing analyses of trends versus unit roots have been carried out with annual and/or seasonally adjusted data, so the results do not preclude the possibility that the unadjusted data are consistent with deterministic trends. Hasza and Fuller (1982) and Dickey, Hasza, and Fuller (1984) address the issue of testing for unit roots (at the first and/or seasonal lag) in seasonally unadjusted data. Ghysels (1987) suggests that the use of seasonally adjusted data may bias unit root tests in the direction of rejecting deterministic trends.

[4] This is also the detrending procedure employed in Kydland and Prescott (1982) and Prescott (1986).

[5] We have also estimated a third model, a second order polynomial function of time, with results extremely similar to those obtained using the procedure advocated by Hodrick and Prescott (1980).

x_t, then the series displays stochastic seasonality.[6] Economic time series typically display both deterministic and stochastic seasonality (Pierce (1978)).

As we emphasized earlier, it is important to allow for deterministic seasonality because a number of phenomena causing the seasonals in economic time series (holidays, school calendars, the weather) tend to produce seasonal peaks and troughs in the same season year after year. The magnitudes of the effects of these factors may change over time, so it might be desirable to allow for time variation in the magnitude of the seasonal dummy coefficients (Stephenson and Farr (1972), Hylleberg (1986)). As we demonstrate in Tables A1–A8 of the appendix, however, the estimated seasonal dummy coefficients are strikingly similar when estimated separately for the first and second half of the post-WWII sample period. We therefore do not find it important to allow for time variation in the seasonal dummy coefficients in highlighting the first order effects that are the topic of this paper.

In order to analyze the seasonal variation in economic times series, we examine the deterministic seasonals, i.e., the regular seasonal peaks and troughs in the series. For this purpose we estimate the equation

$$x_t = \sum_{s=1}^{4} \xi_s d_t^s + \eta_t \tag{2}$$

where η_t is the stochastic component of x_t. Ordinary Least Squares estimates of the seasonal dummy coefficients are consistent.[7] The error term in equation (2), the stochastic component of x_t, need not be serially uncorrelated, however, so the OLS standard errors are not appropriate. We apply the Hansen and Hodrick (1980) technique, as modified by Newey and West (1987), to obtain consistent estimates of the standard errors of the seasonal dummy coefficients.[8]

We employ two procedures to determine the relationships between the seasonal components of different series. The first is to use instrumental variables, with seasonal dummies as the only

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[6] As long as $\beta(L)$ can be infinite order, the model in (1) is consistent with any stationary ARMA model for the stochastic seasonality in x_t. In practice, we find that most of the series we consider are well approximated by an AR(5) plus seasonal dummies, where the coefficients on lags one through three are small and insignificant and the coefficients on lags four and five are larger and more significant. For example, the coefficients on the first five AR terms in real output are .12,-.01, -.14, .36, and -.49. Only the last two are significantly different from zero.

[7] OLS estimates of the seasonal dummy coefficients are also asymptotically efficient (Fuller (1976),pp.388-93), so for samples of the size we employ here there is probably little gain to estimating the model by GLS.

[8] A second procedure for analyzing the seasonality of a series is to examine its spectrum (Nerlove (1964)). One limitation of this approach from our point of view is that the estimated spectrum of a series provides information on the amount of seasonal variation, but not on the timing of this variation. The timing and magnitude of the peaks and troughs in the series are of crucial interest for our purposes. We also note that if a series contains seasonality due to seasonal dummies, its spectrum is not well defined. The theoretical spectrum contains spikes of infinite height at the seasonal frequencies, while the estimated spectrum displays spikes of finite height that increase with sample size (Priestly (1981)).

instruments, to estimate the relation between two variables. The coefficient estimate produced by this IV procedure is identical to that from regressing the seasonal dummy pattern in one variable on the seasonal dummy pattern in the other variable, but it produces a standard error for this coefficient estimate that reflects the sample size used in estimating the seasonal dummy patterns. The second procedure is to examine the coherence and gain of the cross spectrum of the two variables. The coherence function between two series, x_t and y_t, is interpreted as the correlation coefficient by frequency, while the gain function from x_t to y_t is interpreted as the (absolute value of the) regression coefficient of y_t on x_t by frequency. The coherences that we present are those of the seasonal dummy adjusted series; these coherences therefore inform us about the relation between the stochastic seasonality in the two series. We examine these, rather than the coherences of the seasonally unadjusted series, because the coherence of two series containing deterministic seasonality is always unity at the principal seasonal frequency.[9] The gain functions that we report are those relating the pure, seasonally unadjusted data. These are meaningful even in the presence of deterministic seasonality.

III. Basic Facts About the Seasonal Cycle

In this section we document the seasonal patterns in macroeconomic variables and demonstrate that seasonal fluctuations account for a significant share of the non-trend variation in these variables. We present results for both the log growth rates of the variables and for Hodrick-Prescott detrended data, although we focus more on the results for log growth rates. The qualitative results presented in this and the subsequent section of the paper are not sensitive to the choice between growth rates and Hodrick-Prescott detrended data.

A. The Quantitative Importance of Seasonal Fluctuations

Table 1 presents three statistics for each of a set of key quarterly macroeconomic variables for the period 1948:2-1985:4.[10] The left side of the table contains results for log growth rates while the right side contains results for detrended series.[11] Each statistic is computed from a regression of either log growth rates or deviations from trend on seasonal dummies. The first statistic is the standard deviation of the fitted values of the regression; this is an estimate of the standard

[9] This follows from the fact that the spectral power is dominated by the deterministic component.

[10] The sample period is different for Residential Investment (1948:2-1983:4); Monetary Base and Money Multiplier (1959:2-1985:4); and Hours, Nominal and Real Wage (1964:2-1985:4).

[11] For some of the series we examine (the unemployment rate and the nominal interest rate), we detrend the level of the series rather than the log level. For real interest rates, we do not detrend at all. For inventories, we work with the non-detrended values of the change in inventories divided by final sales. The results for these last two variables are reported in the tables for log growth rates.

deviation of the deterministic seasonal component of the dependent variable. The second statistic is the standard error of the regression; this is an estimate of the standard deviation of the business cycle plus stochastic seasonal component of the dependent variable. The third statistic is the R^2 of the regression, which measures the percentage of the variation in the dependent variable due to deterministic seasonality.

The standard deviation of the deterministic seasonal component in the log growth rate of real GNP is estimated to be 5.06%, while that of the deviations from trend is estimated to be 2.87%. Deterministic seasonal fluctuations account for more than 85% of the fluctuations in the rate of growth of real output and more than 55% of the (percentage) deviations from trend. Business cycle fluctuations and/or stochastic seasonal fluctuations represent a relatively small percentage of the fluctuations in real output. Plots of the log level of real output (Figure 1) and the log growth rate of real output (Figure 2) make this point even more clearly. The seasonal fluctuations in output are so large and regular that the timing of the peak or trough quarter for any year is rarely affected by the phase of the business cycle in which that year happens to fall.

Deterministic seasonal fluctuations are present in every major component of GNP, as well as in virtually all other macroeconomic quantity variables such as employment or the money stock. The standard deviation of the seasonal dummies is particularly large in consumption purchases of durables and non-durables, residential fixed investment, and non-defense government purchases, while the fraction of total variation explained by the seasonal dummies is largest for consumption purchases of durables and non-durables. Seasonal dummies also explain a quantitatively important percentage of the fluctuations in the labor market variables (approximately two thirds of the log growth rates), although the magnitude of the seasonal dummies is smaller than in many of the national income accounts. Seasonal dummies account for approximately 50% of the variation in the log growth rate of money.

Seasonal movements in both real and nominal price variables are noticeably smaller than those in quantity variables. For example, the standard deviation of the seasonals in the growth rates of prices is .21%, and seasonal dummies explain only 3.1% of the total variation. The same conclusions hold qualitatively for real interest rates, nominal wages, and real wages. There appears to be no deterministic seasonality in nominal interest rates.

B. The Seasonal Patterns in Macroeconomic Variables

The second step in our examination of the seasonal fluctuations in the economy is to display the estimated seasonal patterns in the macroeconomic variables considered above. These patterns

Table 1: Summary Statistics for Seasonal Dummies, 1948-1985						
	Log Growth Rates			Deviations from Trend		
	Std. Dev. of Dummies	*Std. Err. of Reg.*	R^2	*Std. Dev. of Dummies*	*Std. Err. of Reg.*	R^2
GNP	5.06	1.91	.875	2.87	2.51	.567
Consumption	6.61	1.93	.921	3.73	1.98	.781
Durables	14.24	5.62	.865	7.69	6.70	.571
Non-Durables	11.33	2.11	.967	6.53	1.79	.930
Services	1.09	1.05	.518	.66	1.61	.145
Fixed Investment	8.72	3.77	.843	5.39	6.23	.428
Non-Residential	6.54	4.04	.724	3.47	5.52	.283
Structures	9.98	3.79	.874	6.56	5.38	.598
Producers Durables	7.07	5.87	.591	3.67	6.77	.228
Residential	16.89	6.78	.861	11.45	12.63	.451
Non-Farm Structures	17.51	6.79	.869	12.00	12.78	.469
Farm Structures	21.46	38.92	.233	14.39	26.36	.232
Producers Durables	14.76	22.26	.305	8.83	14.52	.270
Government	3.79	3.50	.540	2.33	5.00	.179
Federal	5.34	6.14	.431	3.24	9.12	.112
Defense	3.91	5.97	.300	2.02	10.00	.039
Other	18.13	17.88	.507	13.18	16.09	.402
State and Local	4.89	2.31	.818	3.38	2.47	.651
Exports	5.09	5.16	.493	2.72	7.23	.124
Imports	3.08	5.14	.264	2.20	6.20	.112
Change in Inventories	1.04	1.32	.384	–	–	–
Final Sales	6.19	1.81	.921	3.48	1.94	.763
Unemployment Rate	.65	.51	.617	.41	.91	.168
Employment	1.50	.89	.739	.92	1.66	.233
Average Hours	.87	.38	.841	.61	.49	.601
Labor Force	1.27	.53	.855	.89	.53	.737
Price Level	.21	1.19	.031	.11	1.67	.004
Nominal Interest Rate	.02	.21	.007	.00	.00	.001
Real Interest Rate	.18	.74	.055	–	–	–
Nominal Wage	.13	.52	.059	.07	.79	.008
Real Wage	.20	.70	.076	.16	1.43	.012
Nominal Money Stock	1.10	1.09	.506	.73	1.10	.305
Nominal Monetary Base	.76	.82	.462	.53	1.28	.147
Money Multiplier	.57	1.00	.243	.38	1.23	.085

The sample period is 1948:2-1985:4, except for Residential Investment (1948:2-1983:4); Monetary Base and Money Multiplier (1959:2-1985:4); and Hours, Nominal and Real Wage (1964:2-1985:4). See footnote 11 for definitions of the variables.

are presented in Table 2, with the log growth rates in Table 2a and the deviations from trend in Table 2b.[12] The entries in the tables are the OLS estimates of the coefficients on the seasonal dummies from Equation (2). In each case we have subtracted the overall mean of the dependent variable from each dummy coefficient; the entries in the tables are therefore interpreted either as the difference between the average growth rate of the variable in that quarter and the overall growth rate, or, as the average percentage deviation of the variable from trend in that quarter. For ease of presentation, we have not included the standard errors on the coefficients.[13] For all variables other than the nominal interest rate, the data reject the null hypothesis of no deterministic seasonality at the 99% level of confidence.[14]

The coefficient estimates in Table 2a show that the growth rate of real output is strongly positive in the second and fourth quarters, strongly negative in the first quarter, and insignificantly negative in the third quarter. Looking at the deviations from trend in Table 2b, we see that output is, on average, well below trend in the first quarter, slightly below trend in the second and third quarters, and well above trend in the fourth quarter. The growth rates from quarter to quarter implied by the deviations from trend are strikingly similar to the results on the growth rates themselves. For example, the implied growth rates in real GNP are -8.07%, 3.74%, -.51%, and 4.84%.

The seasonal patterns in the growth rates and deviations from trend in consumption purchases of durables and non-durables are similar in timing but greater in amplitude than those in output as a whole. The seasonal patterns in government purchases are also dominated by first quarter declines and fourth quarter peaks. Fixed investment behaves somewhat differently, however. It grows most strongly in the second quarter, grows slightly in the third quarter, declines weakly in the fourth quarter, and declines strongly in the first quarter. This implies, consistent with Table 2b, that the deviations from trend reach their peak in the third quarter and their trough in the first quarter.

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12 Tables A1–A8 of the appendix show the same information as in Tables 1 and 2a-2b for two sub-samples of the 1948-1985 period. Although a few variables display somewhat different seasonal patterns in the two periods, the magnitudes of the changes in the patterns are usually small in comparison to the magnitudes of the seasonal patterns themselves. For example, the change in the amplitude of the seasonal dummy pattern in real GNP is only 2.48%, while the amplitude of the pattern is 14.17% in the first sub-sample and 11.69% in the second. Exceptions of importance are noted where they occur; see in particular the discussion of money and output in Section IV.D.

13 The standard errors are in general quite small, implying precise estimates of the seasonal dummy coefficients. For example, the OLS standard errors on the seasonal dummy coefficients in the log growth rate of output are .32, .31, .31, and .31., while the Hansen and Hodrick standard errors are .38, .30, .34, and .30.

14 We have carried out these tests using the Hansen and Hodrick (1980) procedure, with the lag length set equal to 4. The variance-covariance matrix was computed using a damp factor of 1 to insure positive definiteness of the matrix (Doan and Litterman (1986), Newey and West (1987)).

Table 2a: Seasonal Patterns, Log Growth Rates, 1948-1985				
	Q1	Q2	Q3	Q4
GNP	-8.08	3.72	-.49	4.85
Consumption	-10.34	4.27	-.94	7.02
Durables	-21.30	12.73	-4.66	13.23
Non-Durables	-18.22	7.20	-.43	11.45
Services	1.80	-1.15	-.26	-.39
Fixed Investment	-12.33	12.33	.35	-.35
Non-Residential	-8.56	8.09	-3.77	4.23
Structures	-16.33	10.04	5.74	.55
Producers Durables	-4.02	7.29	-9.47	6.20
Residential	-21.50	22.65	8.45	-9.60
Non-Farm Structures	-22.22	23.50	8.78	-10.06
Farm Structures	-33.28	19.46	18.45	-4.63
Producers Durables	-24.61	7.95	2.48	14.18
Government	-6.47	3.23	1.31	1.93
Federal	-7.21	.31	-.93	7.82
Defense	-2.51	3.27	-5.04	4.28
Other	-21.26	-14.59	18.63	17.23
State and Local	-5.37	6.14	3.37	-4.15
Exports	-2.48	4.29	-7.08	5.27
Imports	-1.20	4.69	.24	-3.73
Change in Inventories	1.14	-.39	-.10	-.66
Final Sales	-9.83	5.24	-.81	5.40
Unemployment Rate	1.08	-.67	-.17	-.24
Employment	-2.49	1.46	.25	.79
Average Hours	-1.08	.74	.95	-.61
Labor Force	-1.27	1.55	.96	-1.23
Price Level	-.19	.14	.19	-.14
Nominal Interest Rate	-.00	-.01	-.01	.02
Real Interest Rate	.18	-.16	-.20	.17
Nominal Wage	-.16	-.09	.13	.12
Real Wage	-.05	-.27	.03	.29
Nominal Money Stock	-1.05	-.82	.13	1.74
Nominal Monetary Base	-1.25	-.00	.55	.70
Money Multiplier	.04	-.37	-.52	.93

The sample period is 1948:2-1985:4, except for Residential Investment (1948:2-1983:4); Monetary Base and Money Multiplier (1959:2-1985:4); and Hours, Nominal and Real Wage (1964:2-1985:4). See footnote 11 for definitions of the variables.

Table 2b: Seasonal Patterns, Deviations from Trend, 1948-1985				
	Q1	Q2	Q3	Q4
GNP	-3.76	-.02	-.53	4.31
Consumption	-4.48	-.20	-1.16	5.84
Durables	-10.46	2.16	-2.48	10.77
Non-Durables	-8.07	-.79	-1.27	10.13
Services	1.09	-.08	-.32	-.69
Fixed Investment	-9.37	2.99	3.36	3.02
Non-Residential	-5.30	2.85	-.90	3.35
Structures	-10.56	-.48	5.25	5.79
Producers Durables	-2.36	5.00	-4.44	1.79
Residential	-18.81	3.86	12.29	2.66
Non-Farm Structures	-19.74	3.95	12.85	2.93
Farm Structures	-22.42	-2.84	15.15	10.10
Producers Durables	-10.75	-2.66	-.32	13.72
Government	-3.45	-.45	.94	2.97
Federal	-1.55	-1.59	-2.41	5.55
Defense	-.96	2.32	-2.80	1.44
Other	-2.21	-17.93	1.21	18.93
State and Local	-5.21	.79	4.24	.18
Exports	-1.14	3.44	-3.74	1.44
Imports	-2.80	2.03	2.26	-1.49
Change in Inventories	–	–	–	–
Final Sales	-4.87	.37	-.44	4.95
Unemployment Rate	.66	-.03	-.20	-.43
Employment	-1.45	.07	.30	1.08
Average Hours	-.87	-.14	.81	.20
Labor Force	-1.32	.21	1.18	-.05
Price Level	-.15	-.01	.16	-.00
Nominal Interest Rate	-.01	-.00	-.01	.02
Real Interest Rate	–	–	–	–
Nominal Wage	-.01	-.09	.01	.10
Real Wage	.13	-.17	-.13	.17
Nominal Money Stock	.06	-.66	-.55	1.16
Nominal Monetary Base	-.52	-.42	.13	.81
Money Multiplier	.32	-.07	-.59	.34

The sample period is 1948:2-1985:4, except for Residential Investment (1948:2-1983:4); Monetary Base and Money Multiplier (1959:2-1985:4); and Hours, Nominal and Real Wage (1964:2-1985:4). See footnote 11 for definitions of the variables.

There are of course some exceptions to these overall tendencies. The growth rates and deviations from trend of consumption purchases of services show a first quarter peak rather than a fourth quarter peak. Residential investment shows strong growth in the third quarter as well as in the second quarter.[15] State and local government purchases reach their peak level in the third quarter. None of these exceptions, however, is sufficiently strong to overturn the basic patterns described in the previous paragraph. In particular, the decline in measured output from the fourth quarter to the first quarter occurs in almost every component of economic activity.

The movements in the labor market variables are for the most part procyclical, particularly with respect to the large decrease in output from the fourth quarter to the first quarter. The unemployment rate increases markedly (1 percentage point) from the fourth quarter to the first, and declines somewhat moving into each successive quarter, most notably the second. The labor force and average hours per employee increase moving into the second and again into the third quarter, but (perhaps surprisingly) decrease in the fourth quarter, contrary to the behavior of output. Employment (as measured by the Establishment Survey) falls sharply from the fourth quarter to the first and then rises in each successive quarter, peaking in the fourth (1% above trend).[16] Total hours (average hours times employment) increase only slightly from the third quarter to the fourth quarter. The explanation for the apparently anomalous countercyclical behavior of the labor force may be that there are large numbers of withdrawals by workers whose productivity is low, namely teenagers and agricultural workers.[17]

The seasonal dummy components in the price variables are far smaller than those in the quantity variables. For example, the largest seasonal factor in the price level is only .19% in the log growth rates and .16% in the deviations from trend. Thus, although the seasonal patterns are statistically different from zero in all price variables other than the nominal interest rate, these variables are essentially acyclical at the seasonal frequencies.

The money stock and the monetary base are both generally procyclical, showing significant

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[15] Unlike investment as a whole, investment expenditure on producers' durables tends to be high in the second and fourth quarters. Although this may appear somewhat puzzling, see footnote 19.

[16] Because of the nature of data collection, employment may be overstated in the third quarter in particular. This is because the establishment survey counts as employed anyone who is reported by firms as receiving compensation, including those on vacation. (Employees on strike or taking sick leave are also reported as employed).

[17] Together with John Bound we are in the process of conducting a detailed investigation of the seasonality of monthly labor market variables and their interactions with productivity movements. We do not yet have an explanation for the decline in average hours in the fourth quarter, but we suspect that labor force aggregation issues may be an important part of the story. We note that the data collected by BLS are not affected by the fact that there are more holidays in December than in most other months, since the BLS sampling procedure uses data from the week of the month containing the 12th day of the month.

peaks in the fourth quarter and their largest negative growth rates in the first quarter.[18] The amplitude of the seasonal in the base is smaller than that in M1, reflecting the procyclicality of the money multiplier. Between the base and the money multiplier, it is the base that exhibits the greater seasonal fluctuations. The amplitude of the seasonal in money is considerably smaller than that in output.

The patterns of seasonal fluctuations in economic activity documented above suggest that Christmas and the weather are the primary determinants of the seasonality of economic activity, with Christmas playing the greater role. The large increases in consumption spending on durables and non-durables in the fourth quarter are almost certainly related to Christmas, while the increases in investment spending on structures in the second and third quarter are likely a reflection of the weather conditions in the spring and summer. The increases in purchases of producers' durables in the fourth quarter, rather than in the second or third, may reflect installation of those parts of structures which are put into place indoors at later stages of construction.[19] The large decreases in virtually all kinds of economic activity from the fourth quarter to the first quarter plausibly reflect both the end of the Christmas season and the comparatively poor weather in the first quarter.

IV. The Seasonal Cycle and the Business Cycle

The stylized facts about the economy that collectively constitute the business cycle phenomenon are, for the most part, facts about the correlations between various macroeconomic variables.[20] In this section we examine whether these correlations are present at seasonal as well as at business cycle frequencies. After reviewing a number of specific stylized facts we note that, with respect to all of these correlations, the seasonal cycle is just like the business cycle. This result, that the seasonal cycle and the business cycle are so similar, is perhaps the most intriguing result of the paper.

A. The Behavior of Aggregate Output

The most basic feature of the business cycle is the first one discussed by Lucas (1977) in his now famous article on understanding business cycles: output movements across broadly defined sectors move together. We have demonstrated above that this phenomenon also occurs at the seasonal frequencies, i.e., there is a quantitatively important aggregate seasonal cycle. Indeed, the seasonal cycle is more pronounced than the business cycle for most quantity variables. Although

[18] As we discuss in Section IV.D., the trough in the level of money is in the second quarter rather than the first.

[19] See Table 5.6, p.66, of the July, 1984 *Survey of Current Business* for a list of the components of Investment Purchases of Producers' Durables, which demonstrates the plausibility of this hypothesis.

[20] See especially Burns and Mitchell (1946) Friedman and Schwartz (1963a,1982), and Zarnowitz (1985).

the timing of the seasonal peaks and troughs differs to some extent across different components of output, the overall tendencies are sufficiently similar that a large seasonal cycle remains. As shown in Table 2, the large decline from the fourth quarter to the first quarter occurs "across the board." In the language of traditional NBER business cycle analysis, *conformity* across sectors is high.

A priori reasoning leaves some doubt as to whether one would expect *aggregate* seasonal cycles of the magnitude documented above to be a characteristic of modern economies. Although an agricultural economy might be dominated by a weather induced cycle, it seems implausible that weather effects would be important enough to drive most sectors of, say, the post–WWII United States economy. Some activities, such as residential construction, can proceed at least cost when the weather is "good." For many other activities, however, the temperature extremes associated with summer or winter are costly (high air conditioning/heating costs), so these activities should have spring or autumn peaks.

The large seasonal in activity is particularly surprising relative to standard neo-classical models that assume convex costs of production. If production functions are everywhere concave and there are no seasonals in production or preferences, then output should be produced nearly evenly throughout the year. If there are seasonals in technology or the taste for work, then of course production should be seasonal, *ceteris paribus*, even with concave within period production functions. It is far from obvious, however, what might constitute *aggregate* seasonals in technology.

B. Production Smoothing and the Elasticity of Aggregate Supply

An important point suggested by the striking similarity of the seasonal patterns in production and sales (see Table 2), is that the production smoothing tendencies of the economy at seasonal frequencies are minimal at best. This is a point that has been emphasized at business cycle frequencies by Blinder (1986). While it is true that inventory investment is on average positive in the first quarter, the magnitude of the effect is trivial in comparison to the seasonals in production and sales. This coincidence of final sales and output (the failure of "production smoothing") is documented in detail by Miron and Zeldes (1988), who find that the seasonals in production in 2-digit manufacturing match almost precisely the seasonals in shipments.[21] The seasonal evidence against

[21] The evidence in Miron and Zeldes (1988) is probably more convincing than that provided in this paper, for two reasons. First, Miron and Zeldes use a measure of physical output (the Index of Industrial Production) and an alternate measure of manufacturing output based on national accounts type data and reach the same conclusion using both types of data. Second, their results are for the goods represented by six 2-digit manufacturing industries, all of which are storable over many months if not over several years. The result presented here is for total GNP, which contains a significant component that is not storable, namely the production of retail services. The large increase in measured output in the fourth quarter is presumably due in large part to increases in the provision of retail services, and these must of necessity coincide exactly with retail sales. Stated differently, it is not surprising that there is no production smoothing for a good that cannot be held in inventories.

production smoothing is perhaps even more striking than the business cycle evidence because the anticipated, transitory fluctuations in demand represented by seasonals are precisely the ones that should be most easily smoothed via inventory accumulations (Miron and Zeldes (1988)).

One natural interpretation of the large expansion in output that occurs in the fourth quarter of each year is that there is a taste shift due to Christmas, and with price above marginal cost and marginal cost not increasing rapidly with output (Hall (1988)), firms gladly meet the fourth quarter demand increase. The Christmas taste shift, which raises desired consumption purchases for given permanent income and real interest rates, provides a more concrete example of a consumption shift than those inferred by Hall (1984) at business cycle frequencies. According to this view, Christmas provides an identifying restriction that tells us that the demand curve is shifting and that aggregate supply is highly elastic. This view, of course, is a static one that interprets each period's price and quantity outcome as the intersection of that period's aggregate demand and supply curves.

An alternative framework for understanding the high coincidence of production and sales at seasonal frequencies relies on the view that firms' natural unit of analysis may be a calendar year. Under this scenario, retailers and their suppliers spend the early part of the year planning and preparing for the high demand season in the fourth quarter. An implication is that the first quarter is associated with considerable unmeasured output in the form of strategy sessions, blueprints, or retooling.[22] The fact that physical output is not smoothed may suggest that marginal cost is rather flat, perhaps due to idle labor or excess capacity (Hall (1986)). In the absence of strong discounting, flat marginal cost makes the temporal pattern of production nearly indeterminate. In addition to discounting, the value of waiting to acquire information on the precise pattern and nature of demand, including styles or taste fads, may help explain the tendency of firms to delay production until the fall.[23]

C. The Procyclical Behavior of Labor Productivity

One of the better known stylized facts about business cycles is that labor productivity is procyclical. The empirical elasticity of output with respect to labor input (measured in hours) is not only greater than labor's share in output (the value implied by constant returns and competition)

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[22] Fay and Medoff (1985) provide direct evidence of such unmeasured output at business cycle frequencies.

[23] We should note one potential complication to this story that arises from our work in progress on the seasonality of monthly manufacturing production. In virtually all 2-digit manufacturing industries, there are two features of the seasonal patterns that require mention. First, production falls strongly one to three months before Christmas. This feature of the data is consistent with the discussion above, so long as there are non-trivial lags in moving goods from manufacturing establishments to retail stores. Second, there is a dramatic decline in production in July, followed by a strong increase in August. This feature of the data suggests a more detailed story that involves preferences for vacations in July.

but is actually somewhat greater than unity (e.g., Prescott (1986) reports an elasticity of 1.1).[24] The traditional view of procyclical labor productivity (e.g., Dornbusch and Fischer (1987)), interprets the finding as reflecting labor hoarding during recessions, perhaps coupled with variation in the utilization of capital services (on the latter see also Lucas (1970)).[25] More recently, Kydland and Prescott (1982) and Prescott (1986) have inferred that procyclical labor productivity may reflect shocks to the underlying technology.[26]

Figure 3 shows a plot of real GNP growth and total hours growth against time.[27] At both seasonal and non-seasonal frequencies, peaks in hours growth are associated with magnified peaks in the growth of real GNP, i.e., labor productivity is procyclical. To pin down the magnitude of this relationship at the seasonal as well as at the business cycle frequencies, we present the estimated gain function from hours growth to output growth in Figure 4. At both the seasonal and the conventional business cycle frequencies, the gain function takes on values in the neighborhood of one to one-and-a-half, suggesting that labor productivity is if anything even more procyclical at the seasonal frequencies than it is at the business cycle frequencies.[28]

That labor productivity is particularly procyclical at the seasonal frequencies is hardly surprising if one takes the view that labor hoarding (in the sense of overhead labor as well as idle labor retained by the firm during recessions) combined with variation in aggregate demand is the fundamental source of procyclical productivity. Although there are certainly examples of seasonal work (e.g., migrant farm workers) and seasonal layoffs in the context of more permanent jobs (e.g., construction workers), most jobs are year round. Furthermore, though hours per employee are

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[24] A closely related phenomenon is "Okun's Law" – a one percentage point decrease in unemployment is associated with a two to three percent increase in real GNP. The Okun's law relation reflects the behavior of labor force participation in addition to procyclical labor productivity and procyclical hours per employee.

[25] Rotemberg and Summers (1988) stress that procyclical labor productivity (in the sense of an elasticity of output with respect to labor input of greater than unity) is a very likely consequence of overhead labor, or any labor input that is not instantaneously adjusted as demand varies. Hall (1988) also features labor hoarding but raises the point that this does not account for the fact that total factor productivity (i.e. the Solow residual) is procyclical, as it in fact is, unless price exceeds marginal cost. Hall attributes this excess of price over marginal cost to pervasive monopoly power. Rotemberg and Summers, on the other hand, present a model featuring labor hoarding in which price cannot vary freely with the state of demand, and in which some quantity rationing occurs in the highest demand state. Then price is above marginal cost whenever output is below capacity, and this is sufficient to yield a procyclical Solow residual. As we discuss further below, the Rotemberg and Summers model may be particularly relevant to seasonal variation.

[26] Prescott's model(s) imply elasticities of 1.3 to 1.9, while he estimates the empirical elasticity to be 1.1. Thus one challenge faced by Prescott is to avoid the implication of excessively procyclical productivity, rather than to account for procyclical productivity.

[27] The results discussed in this subsection use the same measure of employment used in Tables 1–2, namely total non-agricultural employment as measured by the Establishment Survey. We have also conducted the analysis with the Household measure of employment, with quite similar results.

[28] We have also computed analogues to Figures 3–4 using the (Hodrick-Prescott) detrended data. These figures are quite similar to those presented in the paper.

somewhat procyclical at the seasonal frequencies, the forty hour a week job still appears to be the modal case. Yet the amount of business faced by firms varies a great deal over the seasons. Hence real GNP varies more than employee hours and labor productivity is procyclical.[29]

On the other hand, it seems hard to account for the seasonal variation in labor productivity by relying solely on changes in technological opportunities (as in Prescott (1986)). We do suspect that the weather plays an important role in the recovery of GNP from the first to the second quarter. By far the largest contribution to procyclical productivity comes from the fourth quarter and is attributable to increased sales of durable goods (the Christmas induced demand expansion), which is not accompanied by much increase in hours of work. Hence, while not denying some role for unembellished shifts in technological opportunities, and while noting that such shifts in the presence of less than fully utilized labor contribute even further to procyclical productivity (i.e., cost shifts as well as demand shifts lead firms to use their hoarded labor more fully), we conclude that the seasonal cycle provides more support for the labor hoarding interpretation of procyclical productivity than for the explanation based on technological opportunities alone.

D. The Relation Between Money and Output

As a result of the pioneering work of Friedman and Schwartz (1963a,1982), all macroeconomists are acutely aware of the strong correlation between movements in the quantity of nominal money and movements in real output. Whether this correlation reflects a causal mechanism running from money to output, and if so which mechanism, is a matter of much dispute. In Keynesian models (e.g., Fischer (1977)), the correlation reflects causation that relies on sticky nominal prices. In the Rational Expectations with Misperceptions models (Lucas (1972,1973,1977)), the correlation also reflects causation from money to output, but it is the result of information imperfections. King and Plosser (1984) illustrate in a real, equilibrium business cycle model that the correlation may reflect reverse causality from output to money, a point made earlier by Keynesian opponents of monetarism (Tobin (1970)).

Figure 5 shows a plot of quarterly real GNP growth against the growth of the nominal money stock (M1). This plot provides for the seasonally unadjusted data an analogue to those in Friedman and Schwartz (1963a,1982) which, using annual and seasonally adjusted data, demonstrate the tendency toward comovement of real output and nominal money at the business cycle frequencies. The plot suggests that the money-output correlation is as impressive at seasonal frequencies as it is

29 We would compute less procyclical labor productivity if labor input is overstated in the third quarter due to vacations, as suggested in footnote 16. Using the measured data, however, we find that output rises from the third quarter to the fourth quarter by 4.85% while total hours increase by only .18%. Thus, we doubt that measurement error accounts for a large fraction of measured procyclical productivity.

at business cycle frequencies.[30] Interpretation of Figure 5 is facilitated by a joint examination with the seasonal factors presented in Table 2. Both money and output show strong growth between the third and fourth quarters. The levels of both peak in the fourth quarter and then fall markedly going into the first quarter. Money and output do not move together between the first and second quarters. Clearly the fourth quarter comovement dominates. The regression of the seasonal pattern in real output growth on the seasonal pattern in nominal money growth gives a coefficient of 2.84, with a standard error of .38.[31] The standard deviation of the seasonal fluctuations in output is consistently greater (by a factor of four) than that in money. Friedman and Schwartz (1963b) found that at the business cycle frequencies the magnitude of the fluctuations in output exceeds that in money by a factor of two.

Figure 6 displays the coherence of the growth rates of money and output after removal of the deterministic seasonal components. This figure allows us to obtain some sense of the comovement of the stochastic seasonality in money and output. The coherence takes on values in the range of .8 at both the seasonal and the business cycle frequencies.

The work of Friedman and Schwartz was responsible for a strong revival of the much older view (e.g., Fisher (1920)) that largely exogenous fluctuations in the nominal money stock play a key causal role in the business cycle. It would seem quite implausible that seasonal fluctuations in output could be driven by monetary factors. Phenomena such as the weather and Christmas apparently play a crucial role in determining the seasonal cycle, and the money stock hardly plays a central part in determining these events (one would hardly wish to maintain that a capricious Paul Volcker conducts monetary experiments at the seasonal frequencies). Rather, the fourth quarter peak in output seems most plausibly attributable to the impulse to real spending associated with Christmas. In this sense, we have for the seasonal cycle an identifying restriction of a sort unavailable for the ordinary business cycle. It seems probable that most of the correlation between money and output at the seasonal frequencies reflects joint endogeneity, in particular an accommodative response of both the base and the money multiplier to high real spending and output in the fourth quarter.

If it is accepted that the seasonal comovements of money and output reflect the endogeneity of money, does this allow us, by analogy, to draw any inference about the similarly high correlations

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[30] Fama (1982) notes that both nominal money and real output are highly seasonal. He does not, however, examine the seasonal patterns in the two variables, and he does not point out that there is a strong correlation between the seasonals in the two variables.

[31] We computed this coefficient and standard error by estimating an IV regression of real output growth on nominal money growth, with seasonal dummies as the only instruments.

associated with the conventional business cycle? We are of two minds on this issue. Applying the principle of parsimony setup by Friedman and Schwartz (1963b) themselves suggests an answer in the affirmative. After finding much less evidence of an independent causal role for money in the "minor" business cycle movements than in the "major " ones, Friedman and Schwartz write, "If money plays an independent role in major movements, is it likely to be almost passive in minor movements? The minor movements can be interpreted as less virulent members of the same species as the major movements. Is not a common explanation for both more appealing than separate explanations?"

On the other hand, one might take the position that two different mechanisms are operative in generating the observed correlations, at least one of them having a causal role for money. The dilemma is well summarized by Minsky's (1963) comment on Friedman and Schwartz: "It seems to me that Friedman and Schwartz really have to choose between accepting a dual theory in which major fluctuations are something different from minor fluctuations or, if they insist on a theory that covers both major and minor cycles, they can accept a view that factors other than narrowly monetary phenomena are important in generating both types of cycles."

Imposing the requirement that the same mechanism explains both the seasonal and the business cycle correlation between money and output presents a challenge to monetarist models such as those of Lucas (1972,1973,1977). In those models, money has real effects due to misperceptions, and the money–output correlation holds for unanticipated but not anticipated money. The seasonal movements of money and output are largely anticipated, so the high seasonal correlation between money and output cannot reflect the misperceptions mechanism that Lucas models. Application of the principle of parsimony would then suggest that money is endogenous rather than causal with respect to the business cycle as well as the seasonal cycle. Of course, it is certainly possible to construct models in which money responds endogenously to seasonal fluctuations but is an exogenous cause of business cycle fluctuations. Nonetheless, we find the similar comovement of money and output at the two sets of frequencies at the very least suggestive of the endogenous money phenomenon discussed by Tobin (1970), King and Plosser (1984), Barro (1987), and others.

E. Prices and Output

The key stylized fact about the price level and real output is that the fluctuations in output are much greater in magnitude than those in prices – prices appear "sticky." This characterization of the relation between prices and output also holds at the seasonal frequencies. From Table 1 we see that the seasonal variation in prices is small relative to the seasonal variation in output (.17 vs

5.06). The non-seasonal variation is also smaller (.95 versus 1.91), although not as markedly.

At first blush, it might appear that one can explain the near constancy of nominal prices over the seasons by an arbitrage argument along the lines of Roll (1972). Most goods, if not strictly classified as durables, have an important durable component (or, perhaps more to the point, are storable if not durable). Arbitrage, this argument goes, then implies that anticipated movements in the prices of these goods cannot be large - if prices were expected to be very much higher in December than in August, rational consumers would shift their purchases of Christmas gifts to an earlier date. This argument falls apart, however, if consumers can hold a nominal asset whose return varies one for one with the nominal price level (Fisher (1930)). Letting p_t be the nominal price of the durable at t, the correct arbitrage condition is

$$p_t = \frac{p_{t+1}}{1+i_t} + div_t$$

where i_t is the nominal interest rate between t and $t+1$ and div_t is any service flow the durable yields at time t, net of storage costs. Consider the case where the service flow is constant. Then the arbitrage condition simply states that the seasonals in prices must be accompanied by seasonals in the nominal interest rate. There is no restriction that the inflation rate cannot be seasonal.

The absence of seasonality in prices, as well as in nominal interest rates, must surely in large part reflect money supply phenomena. We have argued above that the seasonal fluctuations in output are essentially exogenous, and these shifts in output impact on real money demand. Under this scenario, the banking system (including the monetary authority) responds by letting the nominal money supply increase just enough so that the money market clears without any changes in the price level or nominal interest rates.

A number of real (rather than nominal) factors have recently been stressed in the literature with regard to price behavior over the business cycle.[32] These primarily concern the behavior of price *relative* to marginal cost, and they are potentially important in understanding the seasonal behavior of prices in the retail sector, where it appears likely that marginal cost must be high in the peak season. One argument (Stiglitz (1984), Bils (1987)) is that as the level of demand rises, so does the elasticity of demand, resulting in a countercyclical ratio of price to marginal cost. A second example is that of Rotemberg and Summers (1988), in which firms are not able to practice peak load pricing because customers would feel taken advantage of in high demand states. The Rotemberg and Summers story seems particularly applicable to the seasonal predicament of

[32] Ball and Romer (1987) discuss the interactions between real and nominal rigidities in producing the rigidity of prices.

department stores, which appear to reach peak capacity at Christmas time and yet do not raise their prices.

V. Conclusion

The results presented above establish a new set of stylized facts about macroeconomic fluctuations. The two crucial points are that seasonal fluctuations are a dominant source of short term variation in economic activity and that seasonal fluctuations display qualitatively many of the same characteristics as business cycle fluctuations. Both facts should be challenging to researchers aiming at a deeper understanding of macroeconomic fluctuations.

The similarity of the seasonal cycle and the business cycle presents a challenge because, to paraphrase Lucas (1977), "it suggests the possibility of a unified explanation" of both business cycles and seasonal cycles. By trying to understand precisely why the seasonal and the conventional business cycle are so similar we may be able to shed considerable light on all aggregate fluctuations.

Perhaps the most important reason for focussing on the seasonal cycle in economic activity is that there are "identifying restrictions" available for seasonal fluctuations that are not available for conventional business cycle fluctuations. We have attempted to exploit these restrictions above to provide new evidence on the validity of competing explanations of aggregate fluctuations. The knowledge that Christmas provides an exogenous impulse to real spending allows us to identify an important example of endogenous money, and the knowledge that seasonal fluctuations are anticipated casts doubt on the view that the correlation between money and output at business cycle frequencies reflects a causal effect from money to output. We have noted that the high coincidence of production and sales at seasonal frequencies is even more problematic for production smoothing models than the corresponding observations at business cycle frequencies because seasonal fluctuations are anticipated and transitory. Furthermore, we have argued that this suggests that marginal cost does not rise rapidly with output. The large expansion in output in the demand-driven fourth quarter, without much increase in hours of work, prices or interest rates, suggests that aggregate supply is relatively elastic, at least over short periods, and that labor hoarding in the presence of demand fluctuations is perhaps the dominant cause of procyclical productivity.

A strong potential inference that one might be tempted to draw from the observations reported in this paper is that the key stylized facts of the conventional business cycle – the tendency for output to be produced at the last minute (the absence of "production smoothing"), the procyclicality of labor productivity, the comovement of money and output, and the failure of prices to exhibit as much variation as quantities – may have little to do with unanticipated "shocks." Perhaps the implication is that the stylized facts we have stressed are the result of propagation mechanisms that may not be fundamentally different with respect to anticipated versus unanticipated shocks. Thus, while the impulses driving the conventional business cycle may, because of their stochastic nature, not be directly comparable to those driving the seasonal cycle, it may not be entirely surprising that a number of the most readily observed responses are strikingly similar in the two cases.

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Appendix: Sources of Seasonally Unadjusted Data

There are three government agencies that collect, process, and publish most of the major macroeconomic time series. The Federal Reserve Board (FRB) bears responsibility for interest rates, industrial production. and monetary aggregates. The Bureau of Labor Statistics (BLS) has responsibility for consumer and wholesale prices, employment, and unemployment. The Bureau of Economic Analysis of the Department of Commerce (BEA) constructs the National Income and Product Accounts (NIPA) using data collected by the Bureau of the Census. The FRB and BLS collect and publish both seasonally adjusted and unadjusted data. BEA publishes only a limited number of unadjusted series, and it publishes these only irregularly.

The seasonally unadjusted data produced by the FRB are published in complete detail in its regular statistical releases. Some of these unadjusted data are also available in the Federal Reserve Bulletin or in various books.[33] All of the data are available on tape by request from the FRB. The unadjusted data produced by BLS are published in its statistical releases, in the *Monthly Labor Review*, and in a few cases in the Federal Reserve Bulletin. Again, they are also available on tape from BLS. Some of the series from FRB and BLS are available on an unadjusted basis from on-line data retrieval services such as Citibase, Wharton Econometric Forecasting Associates, or Data Resources Incorporated.

Seasonally unadjusted for the NIPA are more difficult to obtain. BEA never publishes any real, seasonally unadjusted series. The reason is the order in which BEA produces its real, seasonally adjusted series. BEA starts with several hundred highly disaggregated nominal quantity series that add up to nominal GNP. It obtains from BLS price indices corresponding to each of these quantities. BEA then seasonally adjusts all the quantity series and all the price indices, deflates all the seasonally adjusted quantity series by the seasonally adjusted price indices, and then aggregates to produce a real, seasonally adjusted value for GNP. BEA also aggregates all the seasonally adjusted nominal quantity series, which produces a value for seasonally adjusted nominal GNP. From these two series, BEA can produce a seasonally adjusted implicit deflator. Given these procedures for calculating seasonally adjusted series, it is a time consuming task to recover the underlying seasonally unadjusted data or to compute a seasonally unadjusted implicit deflator.

Fortunately, BEA does compute and publish seasonally unadjusted nominal quantity series for GNP and most of its major components. It is therefore possible to create real seasonally unadjusted NIPA series by using one of two procedures. The first is to divide the nominal quantity series by a seasonally unadjusted price index such as the Consumer Price Index. This is the procedure we employ above, as well the one employed in Sargent (1976) and Miron (1986). A second procedure is to multiply the real, seasonally adjusted series by the ratio of the nominal unadjusted series to the nominal adjusted series; this is the procedure employed in Miron and Zeldes (1988), Reagan

[33] See, for example, *The Industrial Production Book*, Board of Governors of the Federal Reserve.

and Sheehan (1985), and West (1986).[34] So long as there is not much seasonality in prices, which appears to be the case, this second procedure should provide a good approximation to the first procedure. It is advisable and/or necessary to use the second procedure if there are not appropriate price indices available.[35]

The BEA publishes the seasonally unadjusted nominal quantity data on the major subcomponents of GNP in the *Survey of Current Business*. The quarterly numbers for each year appear irregularly but approximately annually, usually in the July issue. The data are also available on floppy disk from the authors.

Description of the Data Series

National Income and Product Accounts: The definitions of the various components are the standard ones. Quarterly figures. Source: Survey of Current Business, various issues.

Price Level: Consumer Price Index for All Urban Consumers. Quarterly Figures are arithmetic averages of monthly numbers. Source: Citibank.

Nominal Interest Rate: Yield on Treasury bills. Quarterly numbers are sums of monthly returns on 90 day bills with approximately 30 days to maturity. Source: Ibbotson and Sinqufield.

Nominal Wage: Average hourly earnings of private, non-agricultural production workers. Quarterly numbers are averages of monthly numbers. Source: Citibank.

Unemployment Rate: Civilian unemployment rate, total, BLS. Quarterly numbers are averages of monthly numbers. Source: Citibank.

Employment: Non-agricultural employment, Establishment Survey, BLS. Quarterly numbers are averages of monthly numbers. Source: Citibank.

Labor Force: Civilian labor force, total, BLS. Quarterly numbers are averages of monthly numbers. Source: Citibank.

Average Hours: Average weekly hours of production workers, private non-agricultural, BLS. Quarterly numbers are averages of monthly numbers. Source: Citibank.

Money Stock: M1. Quarterly numbers are averages of monthly numbers. Source: Citibank.

Monetary Base: Quarterly numbers are averages of monthly numbers. Source: Citibank.

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34 Since standard seasonal adjustment procedures are approximately equivalent to applying two sided filters, they alter the autocorrelation structure of the series. Series that have been "reseasonalized" by this second procedure may therefore have distorted autocorrelation structures.

35 Miron and Zeldes (1988), Reagan and Sheehan, and West (1985) use the second procedure for precisely this reason. The accounting intricacies involved in calculating an inventory series make it difficult to know what price index is an appropriate deflator.

Table A1: Summary Statistics for Seasonal Dummies, Log Growth Rates, 1948-1966			
	Standard Deviation of Seasonal Dummies	*Standard Error of the Regression*	R^2
GNP	5.34	2.00	.877
Consumption	7.76	1.64	.957
Durables	14.98	6.45	.844
Non-Durables	12.33	2.08	.972
Services	.95	.83	.567
Fixed Investment	9.53	3.92	.856
Non-Residential	6.78	4.78	.667
Structures	9.71	4.38	.831
Producers Durables	7.24	7.33	.494
Residential	17.41	5.58	.907
Non-Farm Structures	17.92	5.62	.910
Farm Structures	13.58	33.38	.142
Producers Durables	16.59	26.36	.284
Government	5.01	4.23	.584
Federal	6.57	7.71	.420
Defense	5.30	7.35	.342
Other	26.33	20.55	.621
State and Local	6.43	1.72	.933
Exports	5.71	5.68	.503
Imports	3.20	5.01	.290
Change in Inventories	1.15	1.38	.409
Final Sales	7.21	1.57	.955
Unemployment Rate	.76	.55	.660
Labor Force	1.46	.52	.888
Employment	1.71	.97	.757
Hours	.86	.34	.867
Price Level	.19	.70	.072
Nominal Interest Rate	.02	.27	.004
Real Interest Rate	.21	.73	.076
Nominal Wage	.19	.42	.175
Real Wage	.11	.59	.037
Nominal Money Stock	1.39	1.69	.805
Nominal Monetary Base	.81	.86	.471
Money Multiplier	.85	.70	.590

The sample period is 1948:2-1966:4, except for the following variables: Monetary Base and Money Multiplier (1959:2-1972:2); and Hours, Nominal Wage and Real Wage (1964:2-1974:4). See footnote 11 for definitions of the variables.

Table A2: Summary Statistics for Seasonal Dummies, Deviations from Trend, 1948-1966			
	Standard Deviation of Seasonal Dummies	*Standard Error of the Regression*	R^2
GNP	3.12	2.28	.651
Consumption	4.37	1.71	.866
Durables	8.00	7.08	.561
Non-Durables	7.12	1.66	.948
Services	1.21	.63	.215
Fixed Investment	6.00	5.31	.561
Non-Residential	3.74	5.75	.297
Structures	6.52	5.65	.572
Producers Durables	3.78	6.89	.232
Residential	11.58	9.35	.605
Non-Farm Structures	11.94	9.73	.601
Farm Structures	9.67	21.54	.168
Producers Durables	10.07	16.88	.262
Government	3.09	6.72	.154
Federal	4.01	12.31	.096
Defense	2.72	13.49	.039
Other	19.07	19.56	.487
State and Local	4.42	2.52	.754
Exports	3.02	7.79	.131
Imports	2.34	5.99	.132
Change in Inventories	–	–	–
Final Sales	4.08	1.56	.872
Unemployment Rate	.50	.88	.243
Labor Force	1.00	.61	.728
Employment	1.11	1.67	.307
Hours	.58	.46	.614
Price Level	.14	1.39	.010
Nominal Interest Rate	.00	.00	.010
Real Interest Rate	–	–	–
Nominal Wage	.17	.51	.103
Real Wage	.05	1.16	.002
Nominal Money Stock	.93	.99	.468
Nominal Monetary Base	.55	1.12	.195
Money Multiplier	.60	.90	.308

The sample period is 1948:2-1966:4, except for the following variables: Monetary Base and Money Multiplier (1959:2-1972:2); and Hours, Nominal Wage and Real Wage (1964:2-1974:4). See footnote 11 for definitions of the variables.

Table A3: Summary Statistics for Seasonal Dummies, Log Growth Rates, 1967-1985			
	Standard Deviation of Seasonal Dummies	*Standard Error of the Regression*	R^2
GNP	4.86	1.63	.899
Consumption	5.55	1.38	.942
Durables	13.66	4.39	.907
Non-Durables	10.47	1.24	.986
Services	1.12	1.31	.580
Fixed Investment	8.08	3.22	.863
Non-Residential	6.44	2.94	.827
Structures	10.33	3.00	.922
Producers Durables	7.11	3.68	.789
Residential	16.65	7.45	.833
Non-Farm Structures	17.36	7.54	.842
Farm Structures	30.64	42.58	.341
Producers Durables	13.06	16.43	.387
Government	2.62	1.64	.719
Federal	4.30	3.36	.621
Defense	2.63	3.51	.359
Other	11.52	7.86	.683
State and Local	3.40	1.49	.839
Exports	4.58	4.49	.510
Imports	3.14	5.19	.267
Change in Inventories	.26	.89	.078
Final Sales	5.23	1.37	.935
Unemployment Rate	.56	.45	.613
Labor Force	1.13	.34	.917
Employment	1.36	.65	.813
Hours	.91	.37	.858
Price Level	.16	.81	.039
Nominal Interest Rate	.03	.67	.002
Real Interest Rate	.17	.74	.048
Nominal Wage	.22	.56	.137
Real Wage	.43	.65	.306
Nominal Money Stock	1.03	.87	.582
Nominal Monetary Base	.73	.65	.556
Money Multiplier	.46	1.11	.144

The sample period is 1967:1-1985:4, except for the following variables: Residential Investment (1967:1-1983:4); Monetary Base and Money Multiplier (1972:3-1985:4); and Hours, Nominal Wage and Real Wage (1975:1-1985:4). See footnote 11 for definitions of the variables.

Table A4: Summary Statistics for Seasonal Dummies, Deviations from Trend, 1967-1985			
	Standard Deviation of Seasonal Dummies	*Standard Error of the Regression*	R^2 R^2
GNP	2.69	2.68	.502
Consumption	3.15	2.00	.712
Durables	7.48	6.21	.592
Non-Durables	6.03	1.59	.935
Services	.74	1.92	.130
Fixed Investment	4.88	6.96	.330
Non-Residential	3.31	5.25	.284
Structures	6.65	5.11	.628
Producers Durables	3.75	6.59	.245
Residential	11.47	15.19	.363
Non-Farm Structures	12.21	15.48	.383
Farm Structures	20.16	29.93	.312
Producers Durables	7.67	11.23	.318
Government	1.63	2.10	.375
Federal	2.58	3.90	.305
Defense	1.44	4.28	.101
Other	8.03	7.94	.505
State and Local	2.39	1.95	.601
Exports	2.51	6.63	.125
Imports	2.15	6.40	.101
Change in Inventories	–	–	–
Final Sales	2.93	2.11	.658
Unemployment Rate	.33	.93	.112
Labor Force	.80	.38	.812
Employment	.77	1.63	.181
Hours	.64	.51	.613
Price Level	.10	1.90	.003
Nominal Interest Rate	.00	.00	.003
Real Interest Rate	–	–	–
Nominal Wage	.17	.97	.030
Real Wage	.30	1.64	.033
Nominal Money Stock	.66	1.11	.260
Nominal Monetary Base	.53	1.43	.118
Money Multiplier	.25	1.45	.028

The sample period is 1967:1-1985:4, except for the following variables: Residential Investment (1967:1-1983:4); Monetary Base and Money Multiplier (1972:3-1985:4); and Hours, Nominal Wage and Real Wage (1975:1-1985:4). See footnote 11 for definitions of the variables.

Table A5: Seasonal Patterns, Log Growth Rates, 1948-1966				
	Q1	Q2	Q3	Q4
GNP	-8.58	3.17	-.18	5.59
Consumption	-11.87	4.74	-1.58	8.71
Durables	-21.68	12.93	-6.20	14.96
Non-Durables	-19.49	6.97	-.98	13.51
Services	1.63	-.67	-.69	-.28
Fixed Investment	-13.76	13.02	1.95	-1.21
Non-Residential	-9.15	8.93	-3.03	3.25
Structures	-15.77	9.61	6.25	-.09
Producers Durables	-4.73	8.83	-9.00	4.90
Residential	-23.59	21.58	10.65	-8.65
Non-Farm Structures	-24.04	22.32	10.97	-9.25
Farm Structures	-18.75	14.75	10.94	-6.94
Producers Durables	-27.26	6.65	2.83	17.79
Government	-8.64	4.07	2.09	2.48
Federal	-9.73	1.02	-.09	8.79
Defense	-4.14	4.74	-6.24	5.65
Other	-28.79	-22.40	32.83	18.35
State and Local	-6.80	7.91	4.66	-5.77
Exports	-3.72	4.79	-7.26	6.19
Imports	-1.34	4.21	1.43	-4.29
Change in Inventories	1.92	-.79	-.14	-1.00
Final Sales	-11.52	5.89	-.82	6.45
Unemployment Rate	1.29	-.73	-.35	-.22
Labor Force	-1.54	1.98	.80	-1.23
Employment	-2.95	1.38	.76	.81
Hours	-.90	.66	1.02	-.78
Price Level	-.25	.09	.26	-.11
Nominal Interest Rate	.01	-.02	-.01	.02
Real Interest Rate	.26	-.11	-.28	.13
Nominal Wage	-.29	.13	.22	-.05
Real Wage	-.16	.05	.15	-.04
Nominal Money Stock	-.60	-1.67	.16	2.10
Nominal Monetary Base	-1.26	-.17	.65	.78
Money Multiplier	.38	-.86	-.71	1.19

The sample period is 1948:2-1966:4, except for the following variables: Monetary Base and Money Multiplier (1959:2-1972:2); and Hours, Nominal Wage and Real Wage (1964:2-1974:4). See footnote 11 for definitions of the variables.

Table A6: Seasonal Patterns, Deviations from Trend, 1948-1966				
	Q1	Q2	Q3	Q4
GNP	-3.73	-.48	-.68	4.90
Consumption	-4.97	-.17	-1.77	6.91
Durables	-10.25	2.48	-3.64	11.41
Non-Durables	-8.21	-1.03	-2.09	11.33
Services	.93	.22	-.45	-.70
Fixed Investment	-10.40	2.63	4.52	3.25
Non-Residential	-6.12	2.96	-.05	3.21
Structures	-10.44	-.69	5.59	5.54
Producers Durables	-3.46	5.50	-3.48	1.44
Residential	-18.94	2.38	12.74	3.82
Non-Farm Structures	-19.49	2.60	13.23	3.67
Farm Structures	-15.38	.15	11.08	4.15
Producers Durables	-10.97	-3.95	-1.32	16.23
Government	-4.47	-.85	1.35	3.97
Federal	-2.54	-2.20	-2.13	6.88
Defense	-1.94	2.97	-3.34	2.31
Other	-2.66	-27.72	5.71	24.67
State and Local	-6.71	.96	5.71	.04
Exports	-1.89	3.58	-3.84	2.15
Imports	-3.01	1.52	2.91	-1.42
Change in Inventories	–	–	–	–
Final Sales	-5.62	.30	-.55	5.87
Unemployment Rate	.80	.02	-.31	-.51
Labor Force	-1.56	.39	1.20	-.03
Employment	-1.69	-.18	.55	1.33
Hours	-.77	-.17	.86	.08
Price Level	-.18	-.07	.18	.06
Nominal Interest Rate	.02	-.01	-.02	.01
Real Interest Rate	–	–	–	–
Nominal Wage	-.27	-.03	.19	.11
Real Wage	.00	-.07	.06	.01
Nominal Money Stock	.60	-.94	-.84	1.19
Nominal Monetary Base	-.47	-.49	.10	.85
Money Multiplier	.73	-.19	-.87	.33

The sample period is 1948:2-1966:4, except for the following variables: Monetary Base and Money Multiplier (1959:2-1972:2); and Hours, Nominal Wage and Real Wage (1964:2-1974:4). See footnote 11 for definitions of the variables.

Table A7: Seasonal Patterns, Log Growth Rates, 1967-85				
	Q1	Q2	Q3	Q4
GNP	-7.58	4.27	-.80	4.11
Consumption	-8.87	3.81	-.29	5.34
Durables	-20.92	12.53	-3.12	11.51
Non-Durables	-17.00	7.45	.14	9.41
Services	1.97	-1.63	-.16	-.50
Fixed Investment	-10.96	11.66	-1.23	.53
Non-Residential	-7.98	7.25	-4.49	5.22
Structures	-16.84	10.45	5.21	1.18
Producers Durables	-3.33	5.76	-9.93	7.50
Residential	-19.51	23.75	6.28	-10.52
Non-Farm Structures	-20.27	24.85	6.36	-10.93
Farm Structures	-48.84	24.51	26.62	-2.28
Producers Durables	-21.77	9.44	2.13	10.20
Government	-4.36	2.41	.55	1.40
Federal	-4.76	-.38	-1.74	6.88
Defense	-.90	1.81	-3.83	2.91
Other	-14.02	-6.70	4.52	16.19
State and Local	-3.97	4.38	2.10	-2.51
Exports	-1.30	3.81	-6.89	4.38
Imports	-1.06	5.17	-.94	-3.17
Change in Inventories	.39	.00	-.07	-.33
Final Sales	-8.20	4.62	-.78	4.36
Unemployment Rate	.88	-.62	.01	-.27
Labor Force	-1.02	1.12	1.12	-1.22
Employment	-2.06	1.54	-.27	.78
Hours	-1.25	.82	.88	-.45
Price Level	-.15	.20	.12	-.17
Nominal Interest Rate	-.04	.00	.00	.03
Real Interest Rate	.11	-.20	-.12	.21
Nominal Wage	-.05	-.31	.05	.31
Real Wage	.06	-.58	-.09	.61
Nominal Money Stock	-1.51	.03	.09	1.38
Nominal Monetary Base	-1.23	.20	.44	.60
Money Multiplier	-.47	.15	-.35	.66

The sample period is 1967:1-1985:4, except for the following variables: Residential Investment (1967:1-1983:4); Monetary Base and Money Multiplier (1972:3-1985:4); and Hours, Nominal Wage and Real Wage (1975:1-1985:4). See footnote 11 for definitions of the variables.

Table A8: Seasonal Patterns, Deviations from Trend, 1967-85				
	Q1	Q2	Q3	Q4
GNP	-3.79	.45	-.38	3.71
Consumption	-4.00	-.23	-.54	4.77
Durables	-10.64	1.84	-1.33	10.13
Non-Durables	-7.94	-.54	-.45	8.93
Services	1.24	-.37	-.19	-.67
Fixed Investment	-8.37	3.37	2.20	2.80
Non-Residential	-4.51	2.75	-1.74	3.50
Structures	-10.67	-.27	4.89	6.04
Producers Durables	-1.29	4.51	-5.38	2.16
Residential	-18.68	5.33	11.84	1.51
Non-Farm Structures	-19.97	5.46	12.41	2.10
Farm Structures	-29.99	-6.28	19.61	16.66
Producers Durables	-10.51	-1.21	.80	10.92
Government	-2.49	-.05	.55	1.99
Federal	-.62	-.95	-2.67	4.23
Defense	-.05	1.69	-2.23	.59
Other	-1.75	-8.14	-3.30	13.19
State and Local	-3.77	.64	2.79	.34
Exports	-.42	3.31	-3.62	.73
Imports	-2.61	2.55	1.61	-1.55
Change in Inventories	–	–	–	–
Final Sales	-4.15	.45	-.33	4.03
Unemployment Rate	.53	-.09	-.08	-.36
Labor Force	-1.09	.02	1.14	-.07
Employment	-1.22	.32	.06	.84
Hours	-.95	-.12	.76	.31
Price Level	-.12	.05	.14	-.07
Nominal Interest Rate	-.03	.01	-.00	.02
Real Interest Rate	–	–	–	–
Nominal Wage	.23	-.15	-.17	.09
Real Wage	.26	-.27	-.32	.33
Nominal Money Stock	-.46	-.39	-.27	1.13
Nominal Monetary Base	-.57	-.35	.15	.78
Money Multiplier	-.08	.07	-.32	.34

The sample period is 1967:1-1985:4, except for the following variables: Residential Investment (1967:1-1983:4); Monetary Base and Money Multiplier (1972:3-1985:4); and Hours, Nominal Wage and Real Wage (1975:1-1985:4). See footnote 11 for definitions of the variables.

Figure 1 Log Level of Real Output

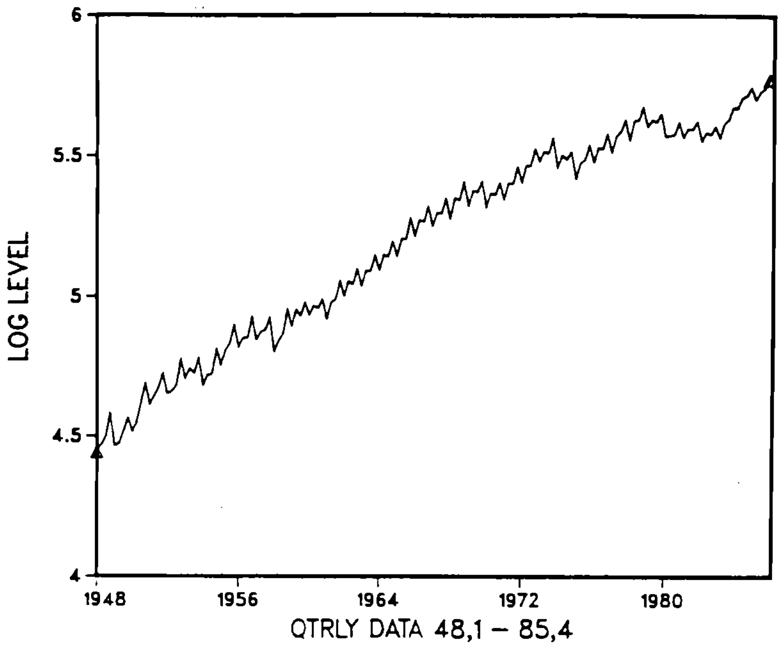

Figure 2 Log Growth Rate of Real Output

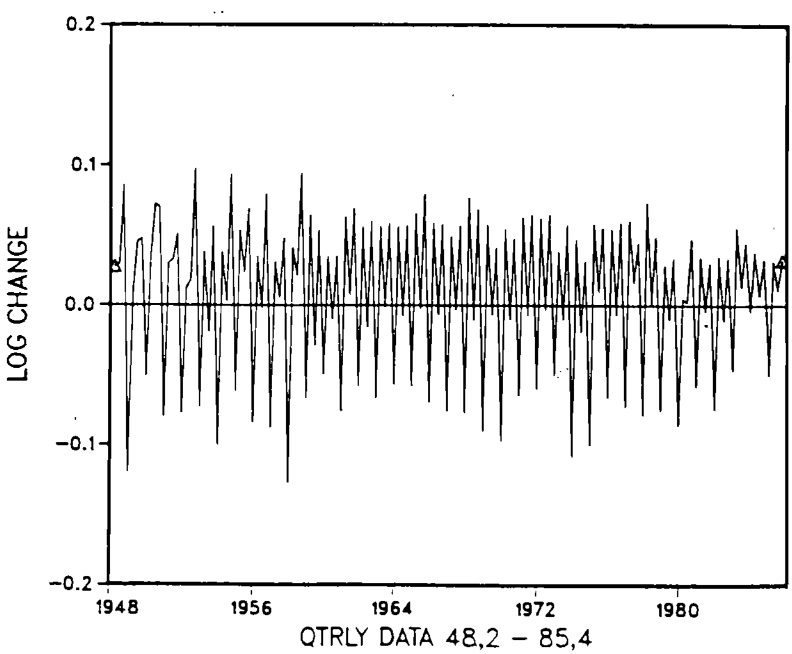

Figure 3

Log Growth Rates:

Real Output and Total Hours

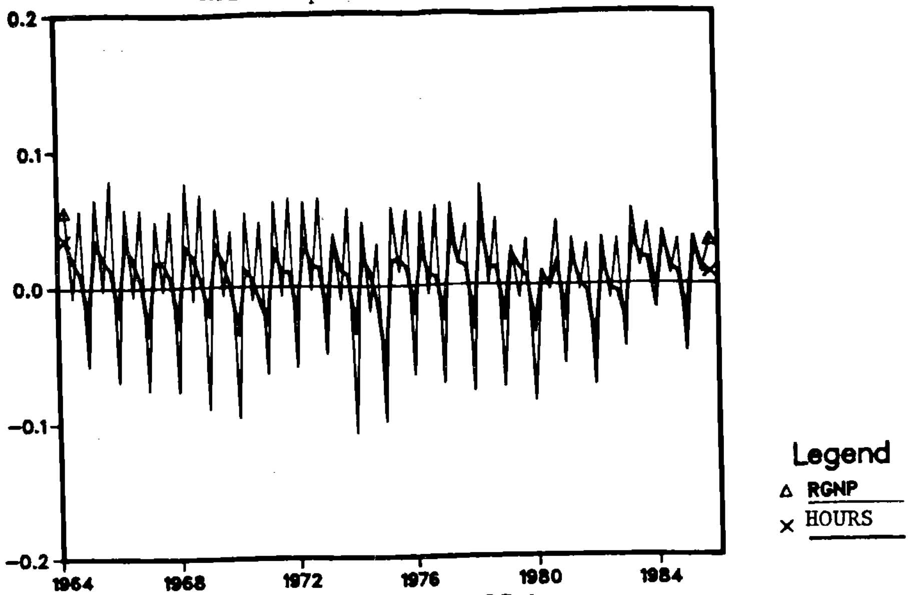

Figure 4

GAIN

Log Growth Rates of Real Output and Total Hours

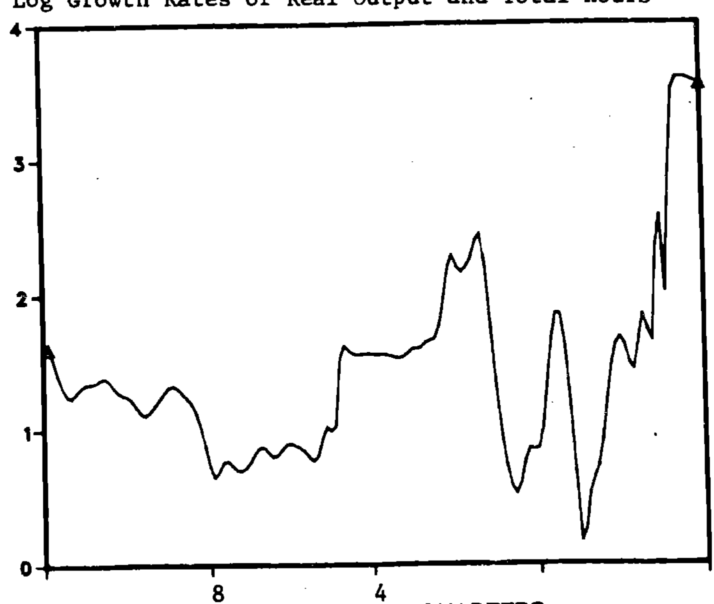

Figure 5

Log Growth Rates of Real Output & Nominal Money

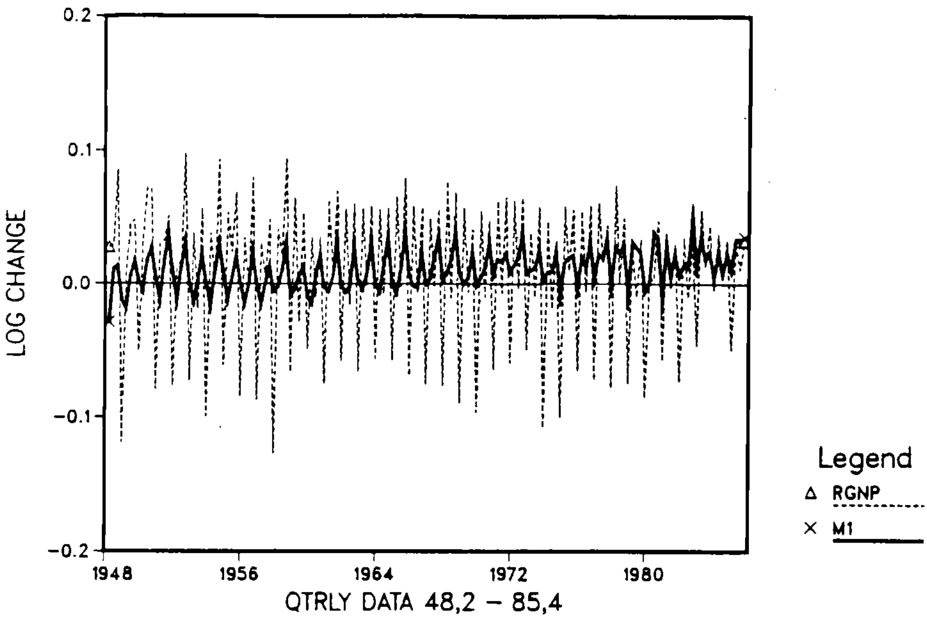

Figure 6

COHERENCE: Seasonal Dummy Adjusted Log Growth Rates of Real Output & Nominal Money