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THE ECONOMICS OF SEASONAL CYCLES

Jeffrey A. Miron

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ABSTRACT

Since macroeconomists first began the systematic study of aggregate data, they have grappled with the fact that most economic time series exhibit substantial seasonal variation. In general, macroeconomists abstract from this seasonal variation, both in their models of cyclical behavior and in their empirical testing of these models. This standard practice is a useful simplification if two key conditions hold. The first is that there are no interactions between seasonal cycles and business cycles: they result from different exogenous factors and different economic propagation mechanisms. The second is that there are no important welfare issues attached to seasonal fluctuations *per se*: optimal government policy toward seasonals is simply to leave them alone.

The purpose of this essay is twofold. It first summarizes recent work demonstrating that seasonal cycles and business cycles are intimately related, displaying similar stylized facts and being driven by similar economic propogation mechanisms. The essay then discusses the possible welfare implications of seasonal cycles, suggesting there is no reasonable presumption they are uninteresting from a welfare or policy perspective. Taken together, these results imply the need for a significant re-orientation in economists' treatment of seasonal fluctuations. Rather than a component of the data to be adjusted away and treated as noise, seasonal fluctuations represent a key topic of economic analysis. They contain significant information about the nature of business cycles, and they require analysis in their own right because they may induce significant welfare losses.

Jeffrey A. Miron
Department of Economics
Boston University
270 Bay State Road
Boston, MA 02215

1. Introduction

Since macroeconomists first began the systematic study of aggregate data, they have grappled with the fact that most economic time series exhibit substantial seasonal variation. In general, macroeconomists abstract from this seasonal variation, both in their models of cyclical behavior and in their empirical testing of these models.[1] This standard practice is a useful simplification if two key conditions hold. The first is that there are no interactions between seasonal cycles and business cycles: they result from different exogenous factors and different economic propagation mechanisms. The second is that there are no important welfare issues attached to seasonal fluctuations *per se*: optimal government policy toward seasonals is simply to leave them alone.

The purpose of this essay is twofold. It first summarizes recent work demonstrating that seasonal cycles and business cycles are intimately related, displaying similar stylized facts and being driven by similar economic propagation mechanisms. The essay then discusses the possible welfare implications of seasonal cycles, suggesting there is no reasonable presumption they are uninteresting from a welfare or policy perspective. Taken together, these results imply the need for a significant re-orientation in economists' treatment of seasonal fluctuations. Rather than a component of the data to be adjusted away and treated as noise, seasonal fluctuations represent a key topic of economic analysis. They contain significant information about the nature of business cycles, and they require analysis in their own right because they may induce significant welfare losses.

Despite the long history of seasonality in economics and statistics, there is no generally agreed upon definition, nor is there a widely accepted view about how seasonality should be treated in empirical or theoretical work. I therefore begin in Section 2 by defining the different types of sea-

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[1] In countries other than the United States, researchers often begin with seasonally unadjusted data and discuss explicitly the statistical assumptions required to accommodate the seasonal variation; see, for example, Davidson, Hendry, Srba and Yeo (1978). Even in these cases, however, there is little discussion of the economic forces producing the seasonal variation.

sonality (deterministic dummies, stationary stochastic seasonality, and non-stationary stochastic seasonality) and discussing the statistical and economic implications of each definition. I then summarize the evidence on what kind of seasonality is present in aggregate data. Two key conclusions emerge from this discussion. First, while many types of seasonality raise important statistical issues, seasonal dummy variation is the only kind that is interesting from the perspective of distinguishing alternative economic models because there are identifying restrictions available for seasonal dummy fluctuations that are not available for the remaining fluctuations, seasonal or otherwise. Second, the data provide evidence mainly of seasonal dummy variation.

With this perspective, the second main section of the paper (Section 3) reviews a number of stylized facts about seasonal fluctuations in the U.S. and other economies. The first facts considered are the seasonal patterns in various aspects of economic activity. It is important to examine these patterns, rather than summary measures of the amount of seasonal variation, because the patterns often show what underlying (exogenous) forces are responsible for seasonal fluctuations. The results presented demonstrate that preference shifts (Christmas) are considerably more important than technology shifts in explaining the important features of observed seasonal patterns. They also suggest that much of the seasonal variation is due to either increasing returns or synergies across economic agents that make it desirable to bunch activity even in the absence of significant technology or preference shifts.

The next set of empirical results demonstrates that several key stylized facts about business cycles characterize seasonal cycles as well. These stylized facts include the comovement of output across sectors, the absence of production smoothing, the comovement of nominal money and real output, and the procyclicality of labor input. I explain that these stylized facts are in many cases more easily explained over the seasonal cycle than over the business cycle because the necessary identifying assumptions are less controversial. The general similarity of seasonal cycles and business cycles with respect to all of these stylized facts suggests that similar mechanisms are at work in producing the two kinds of variation, although the similarity is not by itself conclusive.

The final set of facts presented shows there is a strong correlation across countries and industries between the amount of seasonal variation and the amount of business cycle variation in aggregate variables. I present a general framework for discussing the possible factors that could produce such a correlation and evaluate the plausibility of each of these factors. My conclusion is that the most natural explanation for the cross-sectional correlation between the amounts of seasonal and non-seasonal variation is that seasonal cycles and business cycles result from similar economic propagation mechanisms, even if driven by different exogenous forces.

The third main section of the paper (Section 4) discusses the possible welfare implications of seasonal fluctuations. There are three sorts of models to consider. If seasonality is due to exogenous shifts in preferences or technology and there are no distortions in the economy, then the presence of seasonal variation raises no interesting welfare issues. When there are distortions, however, seasonal fluctuations in preferences and technology interact with these distortions, so policies that smooth seasonal cycles may improve welfare. I discuss two specific distortions (market power and price stickiness) that may interact with seasonal fluctuations in significant ways. Finally, if seasonality results from increasing returns or synergies across agents that produce endogenous cycles with seasonal periodicities, there is no presumption that seasonal cycles are socially optimal in length or amplitude. I conclude this section by discussing existing policies that affect the seasonal variation in real world economies.

The paper concludes in Section 5 by discussing prospects for future research on seasonal cycles.

2. Definitions of and Evidence on Seasonality

Despite the long history of seasonality as a topic of research, there is no generally agreed upon definition of what it means for a series to be seasonal. This section begins by presenting the three main definitions of seasonality and discussing the economic and statistical implications of each kind of seasonality. The remainder of the section summarizes the evidence on which kind of seasonality is present in aggregate data.

2.1 Definitions of Seasonality

The literature on seasonality offers a huge variety of definitions. Most of these definitions, however, can be reasonably approximated by combinations of a much smaller set of definitions, which I discuss below. Hylleberg (1986) provides a more extensive discussion of definitions of seasonality.

The simplest definition of seasonality is the deterministic seasonal dummy definition,

$$x_t = \sum_{s=1}^{S} \alpha_s d_t^s + \epsilon_t \tag{1}$$

where d_t^s is a dummy for season s, α_s is the mean value of x_t in season s, S is the number of seasons, and ϵ_t is a stationary stochastic process. x_t is often a detrended version of some variable X_t. The seasonal dummy definition simply allows for the mean of a series to vary by season, so the presence of seasonal dummy seasonality raises no interesting statistical issues *per se*. The series described by (1) might also display seasonality in the variance; that is, ϵ_t could be seasonally heteroskedastic. This seasonality can be accommodated by estimating standard errors using a robust procedure such as White (1980) or Newey and West (1987).

As a basis for evaluating alternative models of economic fluctuations, it is the seasonal dummy variation in economic series that is of particular interest. The reason is that the factors that might produce such variation are often readily identifiable (e.g., school calendars, the weather, the timing of tax collections, holidays). This means there may be situations in which we have identifying restrictions available for this kind of seasonal variation that are not available for the remaining variation, seasonal or otherwise. For example, a December boom in output can reasonably be attributed to a demand shift (Christmas) as opposed to an improvement in the technology. Similarly, seasonal dummy changes in the economic environment can more plausibly be considered anticipated by economic agents than the forecasts of complicated forecasting schemes attributed to agents *ex post* by econometricians. The identifying restrictions provided by considering the sources of seasonal dummy variation can be exploited in evaluating competing economic hypotheses, as shown below.

A second definition of seasonality involves the presence of seasonal unit roots. The most common specification is

$$x_t = x_{t-12} + \epsilon_t \ , \tag{2}$$

although as emphasized by Hylleberg, Engle, Granger and Yoo (1990) (hereafter HEGY), this particular process imposes strong restrictions on the roots at zero and seasonal frequencies. In the absence of the stochastic shocks, series characterized by seasonal unit roots are indistinguishable from pure seasonal dummy processes (Bell (1987)). When shocks are present, however, the two kinds of processes are fundamentally different. These differences are analogous to those between zero frequency unit root and trend stationary processes. Series containing seasonal unit roots do not have well defined means (by season or otherwise), and they wander from their starting values with no tendency to return. In the case of the process (2), the value of x_t for any month is a random walk, and the shock to this random walk is independent of the shocks to the random walk processes for all other months (assuming ϵ_t is white).

If economic time series are characterized by seasonal unit roots, then estimation of models such as (1) provides spurious results in the sense that the estimated coefficients on the dummies reflect initial conditions plus the accumulation of random shocks. They do not correspond to means of the series by season, which are undefined. Examination of results based on (1) therefore requires the important maintained assumption that seasonal unit roots are absent. In addition, the presence of seasonal unit roots raises many of the same statistical issues as the presence of the zero frequency unit root.[2]

[2] Sims (1988) discusses whether the presence of unit roots is crucial for standard statistical analysis.

As far as economic plausibility is concerned, the seasonal dummy model appears significantly more appealing than the seasonal unit root specification. On the one hand, there are many readily identifiable economic phenomena that might produce seasonal dummy type fluctuations in economic variables. On the other hand, the seasonal unit root specification allows seasonal patterns to drift over time in ways that are highly unlikely. As mentioned above, in the case of the process (2) the value of x_t for any month is a random walk, and the shock to this random walk is independent of the shocks to the random walk processes for all other months. Thus, for example, (2) allows Christmas to occur in July. Although there are undoubtedly economic forces that produce changes in seasonal patterns over time (improved storage technologies, new government fiscal years, the introduction of holidays), it does not follow that the value of a series for a particular month is likely to change randomly in either direction, with no tie to past changes.

It is also important to emphasize that there are many ways one can model seasonal patterns as evolving through time without resort to the seasonal unit root hypothesis. For example, seasonal dummy coefficients may interact with time trends or other variables.[3] Undoubtedly some of this kind of variation is present in aggregate data; the interesting question is how much. Most of the factors that might cause seasonal dummy coefficients to evolve over time also affect the other parameters of economic models. There is no obvious reason why seasonals should be modeled as time varying to a greater degree than other parameters of the economy.

The third widely discussed definition of seasonality is stationary, stochastic seasonality. This is the class of stochastic processes that have peaks in their spectra at seasonal frequencies but are strictly stationary (Nerlove (1964)). Simple examples include

$$x_t = \rho x_{t-S} + \epsilon_t \ , \qquad |\rho| < 1$$

$$x_t = \epsilon_t + \theta \epsilon_{t-S}$$

[3] Osborn and Smith (1989) consider the case where seasonal dummies interact with lagged dependent variables. In general the reduced forms of such models can be written in the form of (1), where the effect of the interactions is to make ϵ_t seasonally heteroskedastic.

where S is the number of seasons. These series are not seasonal in the sense of a seasonal dummy process because their means do not differ across seasons. If initial conditions vary seasonally, and if the degree of serial correlation is high, then these processes may appear similar to seasonal dummy or seasonal unit root processes in finite samples. Their asymptotic properties are different, however, as is their finite sample behavior in most instances.

A crucial fact about series displaying stationary stochastic seasonality is that they are not qualitatively different from series displaying any kind of stationary stochastic variation. Consider, as an example, replacing lag $t - S$ in the two examples given above with lag $t - 1$. The spectra of these processes differ from those of the stochastic seasonality processes in that more of their power is located at the so-called business cycle frequencies as opposed to the so-called seasonal frequencies. For both sets of processes, however, the spectra have power at all frequencies, including both the seasonal frequencies and the business cycle frequencies. The relative amount of power at the two sets of frequencies differs, but there is no logical way to say how much of the power at particular frequencies is due to particular lags in the autoregressive representation.

Given the discussion in the preceding paragraph, there is generally no reason to treat stationary, stochastic seasonality differently from other stationary, stochastic variation. Standard statistical techniques (e.g., Newey and West (1987)) produce consistent coefficient estimates and standard errors in the presence of stationary, stochastic seasonality.[4] If it is an empirical regularity that, after removal of dummies, economic time series display stationary stochastic seasonality, then that fact may be worthy of attention. The evidence provided in Barsky and Miron (1989) and Canova (1990), however, suggests that the magnitude of this regularity is not impressive.[5] Ghysels (1988)

[4] Sims (1974a) argues that seasonally adjusted data can provide better estimates than seasonally unadjusted data under certain conditions. The first condition required is that stationary, stochastic seasonality account for a substantial fraction of the total stationary stochastic variation. As discussed below, this condition does not appear to hold in practice once one accounts for seasonal dummies. The second condition is that the coefficients relating seasonal variation in exogenous to endogenous variables be different from those relating the non-seasonal variation. As Sims (1974a) himself emphasizes, this is a condition that needs to be justified in particular contexts rather than simply assumed *a priori*.

[5] This statement abstracts from seasonality due to trading day or other calendar effects.

argues persuasively that dynamic economic theory does not generally justify decomposing the variation in time series into different frequency bands. There is thus no general justification for modeling the stationary, seasonal stochastic variation separately from other stationary variation.

The final point to make in this discussion is that there is no necessary connection between the different kinds of seasonality discussed above. First, the statistical properties of the three kinds of seasonality are fundamentally different. In addition, there is no presumption and (as far as I am aware) no evidence that the exogenous factors producing the different kinds of variation are related. For example, most weather series display large and significant seasonal dummies but do not display stationary, stochastic seasonality.[6] It is of course possible that there is a connection between the incidence of the different kinds of seasonality, but that is something that needs to be demonstrated rather than assumed. In the absence of such a demonstration, there is no logical reason why the three kinds of seasonality need be considered jointly.

There are thus three main conclusions of this discussion. First, if the data exhibit significant seasonal dummy type variation, that variation is likely to be extremely interesting from the perspective of evaluating alternative economic models because it provides cases where we have plausible identifying restrictions as to the exogenous factors producing variation in endogenous variables. Stationary, stochastic seasonal variation does not as a rule require treatment different from that given to other stationary stochastic variation, and the presence of seasonal unit roots, while potentially important for statistical issues, is not of any obvious interest from the perspective of testing alternative economic theories. Second, it does not make sense to examine estimated seasonal dummy coefficients unless seasonal unit roots can be treated as absent. Third, on *a priori* grounds dummies seem much more likely to be present in economic times series than seasonal unit roots, but *a priori* reasoning can never rule out unit roots entirely. The key question is therefore

[6] I have examined the monthly data on average temperature and total precipitation in each of the forty-eight states. For both temperature and precipitation, only three of the forty-eight states display statistically significant autocorrelation at lag twelve once seasonal dummy effects are removed.

the empirical one: do the data exhibit more evidence of seasonal dummies or seasonal unit roots?

2.2 What Kind of Seasonality Do Aggregate Series Display?

In a recent paper, HEGY develop a procedure for determining whether a series is characterized by deterministic seasonals or unit roots at seasonal frequencies. Their procedure is robust to the presence of stationary, stochastic seasonality, and it improves on earlier procedures (Hasza and Fuller (1982), Dickey, Hasza and Fuller (1984)) by allowing one to distinguish processes that may be integrated at only some of the seasonal frequencies (see HEGY and Beaulieu and Miron (1990a)). The process

$$(1 - B^S)x_t = \epsilon_t$$

or, without $(1 - B)$,

$$(1 + B + B^2 \ldots + B^{S-1})x_t = \epsilon_t$$

has unit roots at *all* of the seasonal frequencies. There is no reason, except for simplicity, to impose the restriction that all of the seasonal roots equal unity.[7]

The HEGY procedure for testing for unit roots at the seasonal and zero frequencies has been applied to quarterly and monthly aggregate series for a number of countries. In most cases the data strongly reject the hypothesis of unit roots at all of the seasonal frequencies, and in many cases they reject the presence of a unit root at any seasonal frequency (Beaulieu and Miron (1990a,1990b,1990c), Osborn (1990)).[8] The results of the seasonal unit root tests are in some cases sensitive to the treatment of residual autocorrelation. When one includes in the estimation equation only those lags of the dependent variable necessary to produce an insignificant Q-statistic for the residuals, or, alternatively, only those lags that appear significant if included in the re-

[7] Box and Jenkins (1976) suggest applying the operator $(1 - B^{12})$ to monthly series to bring about stationarity. Bell and Hilmer (1985) use such a process, less (1-B), as a springboard for their discussion of seasonal adjustment, as do Hilmer and Tiao (1982). Bell (1987) discusses $(1 - B^{12})x_t = (1 - \theta B^{12})\epsilon_t$.

[8] Franses (1990) obtains a similar conclusion for monthly new car registrations in the Netherlands. Otto and Wirjanto (1989) fail to reject the presence of seasonal unit roots in Canadian GDP.

gression, then one consistently rejects the presence of unit roots. If instead one includes a large number of lags to insure that no residual autocorrelation is present, then rejection of seasonal unit roots is much less frequent. This last result presumably reflects low power. As shown in Beaulieu and Miron (1990a) and Otto and Wirjanto (1989), these tests generally have low power against plausible alternatives, and they are biased against rejecting unit roots for plausible specifications of the alternative model.[9] There is thus little evidence of seasonal unit roots in aggregate data.

In addition to casting doubt on the empirical importance of seasonal unit roots, the studies cited above find that, conditioned on the absence of such roots, there are economically large and statistically significant seasonal dummy fluctuations in the data. Although there is evidence that the seasonal dummy patterns are not literally constant over time, but they do not change in the way required by the seasonal unit root hypothesis. In particular, the timing of the peaks and troughs rarely changes across the first and second halves of the sample periods, and the magnitudes of the changes are small relative to the overall amplitude of the seasonal patterns. It is therefore interesting to examine seasonal fluctuations from the perspective of model (1) and determine whether the seasonal dummy patterns indeed provide examples of the kinds of identifying restrictions alluded to above.

3. The Relation Between Seasonal Cycles and Business Cycles

This section of the paper discusses a number of stylized facts about the seasonal fluctuations in aggregate time series for the United States and other countries. The overall point is that these facts are difficult to reconcile with the view that seasonal cycles and business cycles are generated by fundamentally different economic propagation mechanisms. The argument proceeds in three steps. I first display the seasonal patterns in aggregate data and discuss what factors are likely responsible for these patterns. I then show that the patterns imply a general similarity between

[9] Bell and Wilcox (1990) show that sampling error can bias estimates of the Box and Jenkins (1976) "airline" model in the direction of failing to reject the presence of seasonal unit roots.

the stylized facts about seasonal cycles and business cycles. Finally, I show that countries and industries with large business cycles also have large seasonal cycles.

Unless otherwise noted, the results are taken from Barsky and Miron (1989), Beaulieu and Miron (1990b,c) or Beaulieu, MacKie-Mason and Miron (1990) and are based on the model

$$x_t = \sum_{s=1}^{S} \alpha_s d_t^s + \epsilon_t \tag{3}$$

where x_t is the first difference of the log of X_t, the variable of interest.[10] Equation (3) is estimated by OLS, with the standard errors corrected using the Newey and West (1987) procedure. Since the data strongly reject the null hypothesis of no seasonality in almost all cases, the standard errors are not reported to avoid cluttering the tables.

3.1 Seasonal Patterns

Tables 1-5 present the results of estimating (3) for a number of standard aggregate series across a range of countries. The tables contain the demeaned coefficient estimates in addition to three summary statistics. These are the standard deviation of the fitted values of the regression, the standard deviation of the estimated residuals, and the R^2. The tables show that most macroeconomic quantity series are highly seasonal. For example, seasonal dummies usually explain more than 70% of the variation in the growth rate of real GDP. In contrast, the seasonal dummies explain only a small fraction of the variation in the growth rate of the price level (see also Barsky and Warner (1990)). The results in Barsky and Miron (1989) and Beaulieu and Miron (1990c) show that seasonals are essentially absent in nominal interest rates as well.

The pattern of seasonal variation is strikingly similar all over the globe. The most significant feature of this world wide seasonal cycle is a large decline in output from its peak in the fourth quarter to its trough in the first quarter (Table 1). In a typical country GDP rises by 4-5%

[10] Barsky and Miron (1989) demonstrate that the kinds of results discussed below are not sensitive to the method of detrending.

from the third quarter to the fourth and then falls by 5-10% from the fourth quarter to the first. This pattern is consistent across most of the countries considered, including those in the Southern Hemisphere. The natural explanation is an increase in demand for goods associated with Christmas, an explanation supported by the extreme increase in Retail Sales in December (Table 2). There are several countries in the sample that do not celebrate Christmas *per se*, but each celebrates a fourth quarter gift-giving holiday. The first quarter trough in GDP is present across hemispheres, challenging the view that it reflects the effects of winter weather.

A second dramatic feature of the seasonal fluctuations in economic activity, displayed in Table 3, is a slowdown in industrial production at some point during the summer months. This slowdown is evident in all Northern Hemisphere countries, and it is seen dramatically in those of Western Europe. Two aspects of this pattern suggest that it does not result mainly from variation in the weather. First, the slowdown is highly concentrated in a single month in most cases, and the magnitude of the slowdown is extreme in comparison to any obvious change in the weather. Second, the timing of the slowdown (July versus August) differs across countries that have identical timing in the peaks and troughs of their weather patterns.

A more plausible explanation for the summer slowdown relies on synergies across firms or workers that make it optimal to have all activity shut down at the same time (Cooper and Haltiwanger (1989), Hall (1989)). These synergies can occur for a number of reasons. Firms may find it desirable to close at the same time as their upstream or downstream partners. Each firm closes because otherwise, given that all others have closed, it would have to inventory raw materials and work in progress as well as final goods in order to operate during the shut down period. These added costs may outweigh the benefits of smoothing production. In a similar vein firms may wish to have all workers on vacation at the same time so that retooling or maintenance can take place more easily (Cooper and Haltiwanger (1990)), or different workers in the same family may find it desirable to have vacations in the same period.

The conclusion that synergies are probably important in explaining the magnitude of the summer slowdown does not mean that weather plays no role. Instead it is likely that the weather pins down the *timing* of the slowdown as July or August, either because preferences for summer vacations raise the shadow cost of labor or because the weather raises marginal production costs through some channel such as increased air conditioning costs. The weather does not, however, account for the magnitude of the declines in output. The fact that Australia displays a slowdown in manufacturing during the Southern Hemisphere summer period is consistent with this discussion.

It is important to emphasize an important difference between the seasonal patterns presented in Table 1 for total output and those in Table 3 for industrial production. Total output peaks in the fourth quarter, and the December boom in retail sales suggests this peak may occur late in that quarter. Manufacturing activity, however, peaks in most countries early in the fourth quarter (October) or even at the end of the third quarter (September). The explanation for the difference in timing between the two sectors is probably delivery lags. The goods that are produced at the manufacturing level in late summer and early fall move through the wholesale and retail distribution networks over a period of one to three months before ultimately being sold at the retail level in the fourth quarter, particularly December. According to this view, much of measured GDP in the fourth quarter is the provision of retail services.

This overview of the seasonal patterns suggests the following summary of the forces responsible for the seasonal dummy variation in aggregate series. Shifts in demand are a key factor; shifts in technology due to weather are a relatively minor factor; and synergies across economic agents are probably an important factor. This result is interesting relative to long-standing debates about the causes of business cycles. For many decades conventional wisdom regarded demand shifts as the dominant driving force in economic fluctuations. Recently, however, the literature on real business cycles has suggested that shocks to the technology are the most important factor (Prescott (1986)), and the literature on coordination failures has proposed synergies as a key determinant (Cooper and John (1988)). The point emphasized above is that resolution of this debate with respect to seasonal fluctuations turns out to be much easier than resolution with respect to business cycle fluctuations. Section 3.3 below discusses whether the findings about the causes of seasonal cycles derived here apply to business cycles as well.

3.2 The Similarity of the Seasonal Cycle and the Business Cycle

The second important fact about aggregate seasonal cycles is that they display a number of key stylized facts that characterize business cycles. Although there is disagreement amongst macroeconomists about the nature of business cycles, there is broad agreement that a number of well documented empirical regularities are not easily reconciled with simple neo-classical models (Lucas (1977)). I show below that the seasonal cycle displays these same empirical regularities. I then argue that the interpretation of these regularities, at least over the seasonal cycle, is less difficult than over the business cycle because the causes of seasonal cycles, as discussed above, are more easily identified than those of business cycles.

The most important business cycle stylized fact is that an aggregate cycle exists; the production of goods moves together across sectors. This same comovement across sectors characterizes the seasonal cycle. Tables 1 and 3 indicate that seasonal dummies explain an extremely high fraction of the variation in aggregate measures of activity such as GDP and industrial production; this result is unlikely unless the seasonal patterns in different components of output are positively correlated. The evidence in Barsky and Miron (1989) and Beaulieu and Miron (1990b,c) demonstrates directly the positive correlation of seasonal patterns across sectors by examining the components of GDP as well as the behavior of individual manufacturing industries. The comovement of different sectors over the seasonal cycle is surprising in the same way as the comovement over the business cycle. It is easy to think of reasons why particular industries might produce seasonally, but it is not obvious *ex ante* that most industries should have the same seasonal cycle. Some might peak in activity around holidays; others during warm weather; others during cold weather.

The second important business cycle stylized fact, closely related to the first, is the strong absence of production smoothing. As documented by Blinder (1986) and others, inventories do not appear to be used to accommodate the business cycle fluctuations in demand.[11] Instead, production and sales move closely together. This same stylized fact characterizes the seasonal cycle. Miron and Zeldes (1988) and Beaulieu and Miron (1990b,c) present estimates of the seasonals in production and shipments for a number of industries and countries. In each case there is striking similarity between the two seasonal patterns, contrary to what the production smoothing model implies.[12]

At least with respect to seasonal fluctuations, it is also difficult to rationalize the similar timing of production and sales as due to cost smoothing. Eichenbaum (1989) argues that cost smoothing can explain the behavior of inventory investment over the business cycle, but his evidence assumes that costs shocks are unobservable. Miron and Zeldes (1988) find little evidence of cost smoothing with respect to observable cost shocks. As discussed above, it is hard to imagine cost shifts whose magnitude or timing would optimally produce the seasonal pattern of production observed in the data. In addition, even though cost shifts may make it optimal to vary production seasonally, there is no reason why the seasonality of costs need match the seasonality of demand. This is the condition required to explain the similarity of the seasonal patterns in production and sales from a production/cost smoothing perspective.

A third important stylized fact about business cycles is the widely documented comovement of nominal money and real output. The literature has debated two interpretations of this correlation, one leading causally from money to output (e.g., Friedman and Schwartz (1963)), the other causally

[11] Fair (1989) and Braun and Krane (1990) suggest that Blinder's finding may result from inappropriate use of data on deflated nominal values. Using physical units data, they find less evidence against production smoothing. Kahn (1990), however, finds significant evidence against production smoothing using the physical units data provided by Fair as well as the physical units data from Blanchard (1983).

[12] Kayshap and Wilcox (1989), Krane (1990) and Kahn (1990) show that these conclusions hold in many industries using physical units data. Cooper and Haltiwanger (1990) obtain the same result using plant level data on the automobile industry.

from output to money (e.g., King and Plosser (1984)). One can infer from the results in Table 1 for GDP and Table 4 for money that this stylized fact characterizes the seasonal cycle as well as the business cycle. In the fourth quarter, both money and GDP rise dramatically while in the first quarter both fall dramatically. Barsky and Miron (1989) and Beaulieu and Miron (1990c) provide a more formal demonstration of the correlation between the seasonals in money and GDP by estimating IV regressions of money growth on output growth, with seasonal dummies as the only instruments. They also note that the correlation over the seasons between money and consumption, as measured by retail sales, is much higher than that between money and real output, as measured by industrial production (see also Faig (1989)). This is consistent with the evidence in Mankiw and Summers (1986) that over the business cycle money is more highly correlated with consumption than with output.

The correlation of money and GDP over the seasonal cycle is plausibly a good example of the endogenous response of money to the level of transactions in the economy (Barsky and Miron (1989), Barro (1990)). This view in part reflects the fact that there is a readily identified exogenous shift to money demand in December (Christmas). It also reflects the view that well anticipated shifts in money, such as seasonal shifts, cannot affect real output (Lucas (1973)). If prices are sticky with respect to seasonal fluctuations in money, however, then at least some of the correlation between money and output over the seasons can be causal from money to output. Mankiw and Miron (1990) present evidence that the initiation of interest smoothing policies by the Fed in 1914 corresponded with an increase in the amplitude of the seasonal fluctuations in real output. This is the result implied by the presence of prices that are sticky with respect to seasonal fluctuations in the money stock.

The fourth key business cycle stylized fact is the cyclical behavior of labor productivity. In models with constant returns and perfect competition, the empirical elasticity of output with respect to labor input equals labor's share in output. In the data, however, this elasticity always exceeds labor's share and usually exceeds unity, implying that labor productivity is procyclical over the business cycle.[13] Beaulieu and Miron (1990b,c) document this same phenomenon over the seasonal cycle by estimating IV regressions of output growth on labor input growth, with seasonal dummies as the only instruments. The results show that changes in labor input over the seasons are generally associated with more than one for one changes in output.

The main competing explanations for procyclical productivity over the business cycle are labor hoarding in the presence of demand shifts (e.g., Fay and Medoff (1985)) and technology shocks (e.g., Prescott (1986)). Over the seasonal cycle, it is likely that procyclical productivity reflects labor hoarding in response to demand shifts rather than technology shocks alone.[14] In the case of the quarterly GDP data, there is a readily identifiable demand shift in the fourth quarter, and it is implausible that the fourth quarter boom in output reflects improvements in technology. In the case of the monthly data on industrial production, the demand shift is not as well defined (although it is plausibly Christmas combined with a delivery lag), but the pattern of production is even harder to reconcile with shifts in technology.

3.3 Cross-Sectional Correlations

The discussion above has established the general similarity of seasonal cycles and business cycles with respect to a number of stylized facts, and it has suggested that in several cases the competing paradigms for understanding these stylized facts about economic fluctuations can be evaluated convincingly with respect to the seasonal cycle. The conclusion one is tempted to draw from this analysis is that seasonal cycles and business cycles result from the same economic propagation mechanisms, even if driven by fundamentally different exogenous forces. Based on the

[13] For evidence on procyclical labor productivity over the business cycle, see, for example, Fair (1969), Sims (1974b), Fay and Medoff (1985), Prescott (1986), and Summers and Wadhwani (1987), as well as the extensive literature review in Fay (1980).

[14] In the standard discussions of labor hoarding, it is taken as given that the impulse requiring a change in production is demand. There is no reason, however, why firms cannot hoard labor in response to technology shifts. In contrasting the labor hoarding view with the technology shifts view, I am referring explicitly to the version of the latter view in which labor hoarding is absent and procyclical productivity results entirely from shifts in the production function (Prescott (1986)).

evidence presented so far, it is not possible to draw this inference. The similarity of the seasonal cycle and the business cycle with respect to any individual stylized fact, and perhaps the entire collection of stylized facts, may be rationalized as coincidence. The next set of results, however, argues more persuasively that similar mechanisms are at work in propagating seasonal cycles and business cycles.

The basic fact is documented in Figures 1 and 2. Figure 1 presents data for countries while Figure 2 presents data for industries within the United States. Each figure shows the standard deviation of the seasonal component of industrial production for an industry or country on the horizontal axis and the standard deviation of the non-seasonal component on the vertical axis. The key observation is that the two quantities are strongly, positively correlated. As demonstrated in Beaulieu, MacKie-Mason, and Miron (1990), this result holds for a broad range of aggregate variables, including real retail sales, money, prices and interest rates across countries and shipments, inventories, and labor input across industries.

The result is robust with respect to a broad range of alternative specifications. In particular, it is independent of the influence of stationary stochastic seasonality. As discussed above, there is no reason why the presence or importance of stationary stochastic seasonality need be related to the presence or importance of seasonal dummies. Nevertheless, traditional decompositions such as

$$y = trend + deterministic\ seasonals + stochastic\ seasonals + other\ stochastic\ components$$

may suggest that the cross-sectional correlations documented in the figures are generated by mislabeling stochastic seasonality as stochastic non-seasonal variation. The same cross-sectional correlations exist, however, between the standard deviations of the seasonal dummy components of the data and the standard deviations of the X-11 adjusted data. Since X-11 removes stationary stochastic seasonality, this result shows that such seasonality is not responsible for the result, whatever the true relation between deterministic and stationary stochastic seasonality.

As argued in detail in Beaulieu, MacKie-Mason, and Miron (1990), the cross-sectional correlation between seasonal and non-seasonal standard deviations is unlikely to result in a world where the propagation mechanisms producing seasonal and non-seasonal variation are fundamentally different. To see this explicitly, suppose the reduced-form equation for an endogenous variable, y, relates that variable to two exogenous variables x_1 and x_2,

$$y = f(x_1, x_2) \ ,$$

where each of x_1, x_2 is the sum of a stationary non-seasonal component and a deterministic seasonal component,

$$x_1 = x_1^n + x_1^s \ , \qquad x_2 = x_2^n + x_2^s \ .$$

Define $\bar{x}_i$ as the mean of x_i^n plus the mean of x_i^s, and let $\tilde{x}_i^n$ and $\tilde{x}_i^s$ be the deviations from the respective means. The second-order Taylor expansion of $f(\cdot,\cdot)$ around $(\bar{x}_1, \bar{x}_2)$ is

$$y \approx f(\bar{x}_1, \bar{x}_2) + \sum_{i=1}^{2} f_i(\bar{x}_1, \bar{x}_2)(\tilde{x}_i^n + \tilde{x}_i^s) + \frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2} f_{ij}(\bar{x}_1, \bar{x}_2)(\tilde{x}_i^n + \tilde{x}_i^s)(\tilde{x}_j^n + \tilde{x}_j^s) \ ,$$

where subscripts on $f(\cdot,\cdot)$ denote differentiation.[15] Since x_1^s and x_2^s are deterministic we can define seasonal and non-seasonal components of y,

$$y^s = f(\bar{x}_1, \bar{x}_2) + \sum_{i=1}^{2} f_i(\bar{x}_1, \bar{x}_2)\tilde{x}_i^s + \frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2} f_{ij}(\bar{x}_1, \bar{x}_2)(\tilde{x}_i^s \tilde{x}_j^s + E[\tilde{x}_i^n \tilde{x}_j^n | t]) \ , \qquad (4)$$

$$y^n = y - y^s \ ,$$

where $E[\tilde{x}_i^n \tilde{x}_j^n | t]$ denotes the expectation conditional on the season.

Assume that the exogenous factors producing seasonal variation are distinct from those producing business cycle variation, e.g., $x_1^n = x_2^s = 0$. Assume also that $f(\cdot,\cdot)$ is linear in x_1 and x_2. Then (4) reduces to

$$y^s = f(\bar{x}_1, \bar{x}_2) + f_1(\bar{x}_1, \bar{x}_2)\tilde{x}_1^s \ ,$$

[15] This representation assumes that x_1^n and x_2^n are stationary and ergodic. If the assumption is violated, then one can take $\bar{x}_1$ and $\bar{x}_2$ to be the initial values of x_1 and x_2 respectively. In this case, a Taylor approximation will likely be poor for t much larger than its initial value.

$$y^n = f_2(\bar{x}_1, \bar{x}_2)\bar{x}_2^n \quad .$$

This model implies a cross-sectional correlation between the seasonal and non-seasonal standard deviations of y under either of two conditions. The first is a cross-sectional correlation between the standard deviation of the seasonal component of x_1 and the standard deviation of the non-seasonal component of x_2. As shown in Beaulieu, MacKie-Mason, and Miron (1990), this condition is unlikely to hold in many plausible models. The other condition is a cross-sectional correlation between $f_1(\bar{x}_1, \bar{x}_2)$ and $f_2(\bar{x}_1, \bar{x}_2)$, which means that sectors in which the effect of x_1^s on y^s is large coincide with those in which the effect of x_2^n on y^n is large. This is exactly the statement that the mechanism transmitting seasonal variation is similar to that producing business cycle variation.[16]

A simple example illustrates the basic arguments made above. Assume that business cycles are due to monetary surprises while seasonal cycles result from seasonal shifts in the technology. Under this assumption, the correlation across countries between the amounts of seasonal and cyclical variation in output reflects the fact that countries in which the central bank puts big surprises into the money stock are also the countries in which the seasonal fluctuations in the technology are the most dramatic. There is no obvious reason for this condition to hold.

One highly plausible mechanism that does give rise to the observed, positive, cross-sectional correlations is a model in which the elasticity of output increases with the amount of variation in demand, and in which either anticipated or unanticipated variation has this effect. This is exactly what occurs if firms make capacity choices that are binding in the short term and then respond optimally, given capacity, to fluctuations in demand. Beaulieu, MacKie-Mason and Miron (1990) present a model of this kind. Their model provides only one of many possible explanations for the empirical result documented above, but it demonstrates that there exist well articulated models

[16] As noted in Beaulieu, MacKie-Mason, and Miron (1990), non-linearity in $f(\cdot,\cdot)$ can also produce a cross-sectional correlation between the seasonal and non-seasonal standard deviations of y, but the correlation can be of either sign. Thus, this effect may be part of the explanation for the results discussed here, but it is necessary to explain which non-linearity is important and demonstrate that it implies the positive correlations observed in the data.

that are consistent with the facts and in which the propagation mechanism is indeed similar with respect to seasonal and non-seasonal fluctuations in exogenous variables.

3.4 Summary

This section demonstrates that seasonal cycles explain a large fraction of the variation in aggregate economic activity and are similar to business cycles in many key respects. It also argues that the two kinds of cycles result from the same economic propagation mechanism. These conclusions should not be taken at face value; to make them fully convincing requires the specification and testing of formal models incorporating both seasonal and business cycle fluctuations. The evidence provided here, however, constitutes a strong indictment of the view that the two kinds of fluctuations can be studied correctly in isolation.

4. The Welfare Implications of Seasonal Fluctuations

As discussed above, there are two possible justifications for the standard practice of studying business cycle fluctuations while ignoring the seasonal fluctuations. One is that the two kinds of fluctuations can be studied in isolation without significant loss of information about either. The evidence presented so far suggests this justification is not well founded. The second possible justification is that seasonal fluctuations have no interesting welfare consequences and are therefore associated with no interesting policy issues. In this section I demonstrate that seasonal fluctuations *do* raise welfare and policy questions and are therefore of interest *per se*, even if they are unrelated to business cycle fluctuations. I also comment on existing government policies that affect seasonal fluctuations.

4.1 Efficient Models of Seasonality

Until recently, aggregate fluctuations were commonly viewed as involving significant welfare losses, and the desirability of reducing the amplitude of economic fluctuations was taken as given.

This notion was challenged by the class of real business cycle models initiated by Kydland and Prescott (1982) and Long and Plosser (1983). In these models, fluctuations result from changes in the underlying technology, and since there are no sources of inefficiency in the economy, these fluctuations represent the economy's efficient response to changes in technological opportunities. In this world, stabilization reduces welfare. The real business cycle literature has shown that the magnitude of the fluctuations in output is approximately what one should expect based on the assumptions of competition, constant returns and the properties of the estimated Solow residual.

This view of aggregate fluctuations has been extended to seasonal fluctuations in two recent papers (Braun and Evans (1990), Chatterjee and Ravikumar (1990)). These papers modify the standard real business cycle model by allowing seasonal shifts in tastes and technology (Braun and Evans also allow seasonal shifts in government purchases), and they compare the seasonal implications of their models to the observed seasonal movements in the data. They find that the models are in many respects consistent with observed seasonal fluctuations, although they fail to match the behavior of some key variables. The Braun and Evans (1990) specification does not capture the seasonals in fourth quarter investment or labor hours; the Chatterjee and Ravikumar (1990) specification has difficulty with labor hours and the real wage.

These models illustrate how seasonal variation can be incorporated into models of aggregate fluctuations in a way that has no implications for welfare or policy. The seasonal shifts in preferences and technology imply seasonal changes in output and its composition, as well as in labor input, but this variation is the efficient response of the economy to changes in preferences or technological opportunities.[17] Policies that dampen seasonal fluctuations in such a world reduce welfare by preventing the economy from optimally shifting production into high productivity or high utility seasons. Of course, policies that increase the amplitude of seasonal fluctuations are costly as well.

[17] Output is not storable in these models, so there is an incentive to produce in the seasons when consumers prefer consumption.

4.2 Inefficient Models with Exogenous Seasonality

The first setting in which seasonality raises interesting welfare questions is one in which seasonality results from shifts in preferences and technology, as in the models discussed above, but the interaction of seasonal fluctuations with some distortion increases the effects of the distortion. There is nothing special about seasonal fluctuations in this regard; any aspect of the economy may interact with a distortion, thereby affecting welfare. There is thus no presumption that policy should target seasonal fluctuations, and in many cases it is preferable to target the distortion directly. The point I raise here is that there are plausible cases where the interactions between seasonal fluctuations in preferences or technology and distortions are quantitatively important and where stabilizing seasonal fluctuations may be an appropriate policy.

One model that may imply significant interactions between seasonal fluctuations and economic distortions is one in which firms make costly investments in capacity that are binding in the short to medium term. These investments need not be for physical capital. Any kind of commitment, such as a budget plan, can reduce flexibility in costly ways. In this setting, a crucial determinant of desired capacity is the amount of variation in demand. Under plausible assumptions, increased variation in demand, including fully predictable variation, causes firms to rationally hold capacity that is not fully utilized in the off-season. There are numerous examples of seasonally underutilized capacity: beach resorts during the winter, churches or football stadiums on days other than Sunday, or highways at night. Table 3 suggests that the same phenomenon occurs in the manufacturing sector, since it is implausible that the capital stock changes much over the period from June to August while the rate of production changes dramatically in most countries and industries.

As discussed above, if there are no distortions in the economy there is nothing sub-optimal about unused capacity *per se*. If, however, firms operate in a non-competitive environment, the quantity of capacity chosen can be excessive (Spence (1976), Dixit and Stiglitz (1977)). More importantly for the purposes here, the extent of unused capacity increases with the variability of demand (Beaulieu, MacKie-Mason, and Miron (1990)). By stabilizing the seasonal variation in demand, policy reduces firms' optimal choice of capacity. Since the degree to which firms' capacity choices are excessive depends on the determinants of those choices, it is possible that by reducing demand variability policy reduces the extent to which the laissez-faire capacity choices deviate from the social planner's choices. Policy can therefore have a first-order effect on output and welfare.

The interactions between seasonal variation and economic distortion that arise in the class of models described above does not necessarily provide a motivation for stabilizing the seasonal fluctuations in demand. In this class of models, private capacity choices can be insufficient as well as excessive (Mankiw and Whinston (1986)). In addition, if demand curves shift seasonally because consumers desire seasonal consumption (Miron (1986a), Osborn (1988,1989)), optimal policy will not smooth the seasonal variation entirely. The class of models described above nevertheless illustrates one possible interaction between seasonal fluctuation and economic distortions. It is also one possible rationalization of Kuznets' (1933) suggestion that policy dampen seasonal fluctuations in order to reduce the waste associated with seasonal excess capacity.

A second model in which seasonal fluctuations plausibly interact with a distortion in a quantitatively important way, and in which the presumption is stronger that policy should smooth seasonal fluctuations, is one in which firms face costs of changing prices. If prices must be held constant over high and low demand seasons, then firms' capacity choices are in general excessive, even in an otherwise efficient economy (Rotemberg (1988)). The size of the distortion in capacity choices is a function of the variation in the states of demand (in the limit where there is no variation, no distortion is possible), so stabilizing demand seasonally increases welfare. The issue raised here is directly relevant to the widespread central bank policy of eliminating nominal interest rate seasonals (see below).

4.3 Inefficient Models with Endogenous Seasonality

The perspective adopted so far has been one in which the seasonal variation in economic activity is treated as exogenous; it results from shifts in preferences and technology. The discussion above of the seasonal patterns in economic activity, however, shows that significant features of the seasonal patterns are not easily reconciled with such explanations. Instead, there appear to be examples of endogenous seasonality, i.e., changes in economic activity that arise because increasing returns or synergies across agents make it desirable to concentrate activity in particular seasons, even when these seasons are not substantially different from the ones in which less activity takes place.[18]

The best example of such an endogenous cycle is weekends. As discussed in Hall (1989), much agglomeration of economic activity appears excessive relative to the observable exogenous factors that might explain the agglomeration; examples include cities, business cycles, holidays, seasonal cycles, days versus nights, and weekends. For most of these examples, it is plausible that some of the agglomeration reflects changes in tastes and technology, but in the case of weekends no such ambiguity arises. The preferences and technology of the economy do not know whether it is Tuesday or Sunday. The fact that activity has a seven day cycle is therefore a result of agents endogenously choosing to bunch activity rather than the result of agents adjusting to exogenous changes in the economic environment.

The literature on business cycles has recently focused considerable attention on models with endogenous fluctuations (e.g., Grandmont (1985), Shleifer (1986), Murphy, Shleifer, and Vishny (1989), Diamond and Fudenberg (1989), Boldrin and Woodford (1990), Woodford (1990)). There are two main mechanisms that give rise to endogenous cycles. In some models, any given agent's level of activity increases the attractiveness of similar activity for other economic agents. This implies that agents coordinate on particular periods in which to produce, even though the prefer-

[18] The discussion in this section borrows heavily from Hall (1989).

ences and technology are no different than in adjacent periods. The other main factor producing bunching is increasing returns, which make it desirable to bunch the production of goods so long as they are storable.

In general, the models cited above display two features of interest here. First, they have multiple equilibria, and at least some of these equilibria are periodic. In this sense the models are better candidates as models of seasonal cycles than as models of business cycles. Second, there is no presumption that the laissez-faire outcomes are socially optimal. In many cases the equilibria can be Pareto ranked, but there is no guarantee that the best equilibrium occurs. Thus, these models as applied to the seasons suggest that the bunching of activity over the year may be inefficient. They do not clearly indicate whether the private degree of bunching is too great or too small.

One potentially important difference between the application of these models to seasonal cycles as opposed to business cycles is that for seasonal cycles there are observable factors that help pin down the equilibrium that occurs, even though such factors do not by themselves produce substantial bunching. Thus, the slowdowns in industrial production that take place in either July or August appear too great to be due solely to the difference in the weather between the month of the slowdown and adjacent months, but the fact that the weather is better during the summer than during other times of the year does determine why the lack of activity coordinates on some month during the summer. It is interesting to note in this regard that for weekends, where there is no technological factor that pins down a particular day of the week as the low productivity period, different cultures choose different Sabbaths (Friday for Moslems, Saturdays for Jews, Sundays for Christians), even though all choose a seven day week.

With these models as background, it is useful to reconsider the summer slowdown periods documented above.[19] On the production side, any individual firm has an incentive to shut down

[19] See Cooper and Haltiwanger (1989) for a discussion of the issues considered here in the context of business cycle fluctuations.

in July given that all other firms do the same. The individual firm may not capture the total benefits of coordinating its activity level with that of other firms, however, suggesting that from this perspective the private degree of bunching may be insufficient. Alternatively, in choosing to concentrate production in a particular period each firm likely ignores any congestion effects that its activities might have with respect to scarce general capacity (e.g., electric power generation), so there are forces suggesting the private degree of bunching may be excessive. On the consumer side, every individual may prefer July relative to June or August as a vacation month. In making that choice, however, the individual does not take into account the crowding effect on others of his presence on the beach. Under plausible conditions, too many individuals will choose to take their vacations in the "best" month. Thus, as noted above, the seasonal cycles that arise endogenously as the result of synergies across agents are not necessarily optimal, but there is no presumption they too large or too small.

4.4 Existing Government Policies Toward Seasonality

The suggestions made above about the possible welfare effects of seasonal fluctuations need to be developed more fully in order to isolate the direction and magnitude of the welfare effects. My point here is to dispute the presumption that seasonal variation is uninteresting from a welfare or policy perspective and to suggest there may be a case for stabilizing seasonal fluctuations. One can object that designing a policy to optimally shift a fraction of vacations from July to August, or to reduce the concentration of work on weekdays relative to weekends, requires too much detailed information about the structure of the economy, even if shown desirable on theoretical grounds. Nevertheless, since it is easier to smooth seasonal cycles than business cycles (long and variable lags are not a problem), such policies deserve further consideration. Alternatively, even if one accepts the exogenous, efficient view of seasonality, it is important to determine that policies do not distort the economy's seasonal fluctuations from their laissez-faire values. I therefore turn to discussing existing government policies that may have significant effects on seasonal variation.

A potentially important example of a policy that affects seasonal fluctuations is the provision of imperfectly experienced rated unemployment insurance (UI). As discussed in Feldstein (1976,1978) and Topel (1984), imperfectly experience rated UI subsidizes temporary layoffs, and one important category of such layoffs is seasonal layoffs. By subsidizing seasonal layoffs, UI tends to make seasonal fluctuations in some industries larger than they otherwise would be, and it transfers resources, *ceteris paribus*, from non-seasonal industries to seasonal ones (Topel and Welch (1980), Deere (1989)).

An important example of an explicitly seasonal policy is the practice of most central banks of smoothing nominal interest rates over the seasons (Shiller (1980), Clark (1984), Mankiw and Miron (1986), Miron (1986b), Barsky, Mankiw, Miron and Weil (1988)). The impact and desirability of this policy depends crucially on the degree of price stickiness in the economy (Mankiw and Miron (1990)). In a fully classical world, where all prices are fully flexible with respect to changes in the nominal money stock, alternative seasonal monetary policies affect only the seasonality of the nominal interest rate and real balances. It is therefore generally optimal for the monetary authority to hold the nominal rate constant over the seasons (i.e., accommodate seasonal shifts in asset demands) because this minimizes the intertemporal tax distortion associated with the collection of seignorage (see also Chatterjee (1988)).

If prices are not fully flexible in response to seasonal changes in money, then alternative seasonal monetary policies have real effects that may make the policy of smoothing nominal interest rates less desirable. As discussed above, if prices are sticky over the seasons firms are likely to hold excess capacity, and the extent of such excess capacity increases with the amount of seasonal variation in demand. The Fed's policy of accommodating seasonal aggregate demand shifts, therefore, may significantly increase the amount of excess capacity that firms hold, thereby lowering welfare.

The other important government policy that tends to produce seasonal cycles is legally mandated holidays. By shutting down on certain days of the year, the government encourages the concentration of leisure time in certain seasons. As discussed above, such policies may or may not be welfare improving. If there are fixed costs of going to work as well as synergies from having everyone work at the same time, it may be desirable for the government to help private agents coordinate on a particular equilibrium in which bunching occurs (e.g., daylight savings time). In considering such policies, however, the congestion effects must be balanced against the synergies. The question of the optimum number of holidays is thus a non-trivial problem for economic analysis.

5. Discussion

This essay represents a progress report on a continuing effort to examine the importance of seasonality for the understanding of aggregate economic fluctuations. At a general level, the research completed so far establishes a stylized view of what the seasonal cycle looks like; it makes a case that there is information to be gained both empirically and theoretically by considering seasonal and business cycles jointly; and it raises the issue of whether seasonal cycles deserve serious consideration as candidates for welfare and policy analysis. As discussed above, recent analysis of seasonality also provides more specific information about the nature of economic fluctuations. Most importantly perhaps, the finding of a general similarity between the seasonal cycle and the business cycle suggests that the economic propagation mechanism may not be fundamentally different with respect to anticipated versus unanticipated shocks.

The logical next step in the analysis of seasonal cycles is the articulation of specific models of aggregate behavior that account for both the seasonal and business cycle facts discussed above. There are some recent examples of models that attempt to do this (Ghysels (1988,1990), Hansen and Sargent (1990), Hall (1989), Todd (1989), Braun and Evans (1900), Chatterjee and Ravikumar (1990), Cooper and Haltiwanger (1990), Beaulieu, MacKie-Mason and Miron (1990)), but the literature is still in its infancy. The claim offered here is that when such models have been developed and tested against both the seasonal and cyclical components of the data, they will shed significant new light on the nature of economic fluctuations.

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Table 1: Real Gross Domestic Product, Log Growth Rates (Quarterly)									
	Sample Period	*Std. Dev. of Seasonals*	*Std. Dev. of Residuals*	R^2	Q1	Q2	Q3	Q4
Argentina	1977:2–1987:2	3.87	3.53	.546	-6.09	2.53	-.39	3.95
Australia	1960:2–1987:3	9.02	2.31	.938	-14.37	.09	4.05	10.23
Austria	1973:2–1987:3	9.07	1.12	.985	-15.60	6.52	5.66	3.42
Canada	1961:2–1987:3	6.17	2.07	.899	-6.76	4.59	7.49	-5.32
Finland	1970:2–1987:2	7.40	2.95	.863	-12.38	4.50	1.39	6.49
Germany	1960:2–1987:3	4.75	2.51	.782	-7.61	3.24	4.64	-.27
Italy	1970:2–1984:4	5.68	1.62	.924	-9.57	4.72	.78	4.07
Japan	1965:2–1987:1	10.83	2.19	.961	-17.22	.05	5.40	11.77
Netherlands	1977:2–1987:4	5.39	2.52	.821	-4.04	6.41	-6.31	3.93
Norway	1978:2–1987:4	3.28	1.93	.742	-4.17	-2.18	2.78	3.57
Sweden	1970:2–1987:3	11.56	1.87	.974	-9.38	.42	-9.81	18.76
Taiwan	1961:2–1987:3	3.56	3.44	.517	-3.54	1.02	-2.87	5.39
United King.	1955:2–1987:3	3.46	2.15	.721	-5.90	1.65	1.22	3.03
United States	1948:2–1985:4	5.13	1.84	.886	-8.17	3.96	-.56	4.77

Notes for Tables 1-5:

1. Source: Beaulieu and Miron (1990c)

Table 2: Real Retail Sales, Log Growth Rates (Monthly)

	Sample Period	*Std. Dev. of Seasonals*	*Std. Dev. of Residuals*	R^2
Australia	1961:5–1987:11	12.73	3.17	.942
Austria	1960:2–1987:10	17.80	5.53	.912
Belgium	1969:2–1987:9	11.92	3.73	.911
Canada	1960:2–1987:11	12.72	4.00	.910
Denmark	1960:2–1987:11	12.83	5.57	.841
Finland	1960:2–1987:9	15.71	6.21	.865
France	1960:2–1987:12	20.32	6.32	.912
Germany	1960:2–1987:11	15.02	4.60	.914
Greece	1974:7–1987:10	10.62	5.29	.801
Italy	1970:2–1987:8	19.26	5.52	.924
Japan	1960:2–1986:10	16.50	2.93	.969
Netherlands	1960:2–1987:11	8.76	5.89	.689
Norway	1960:2–1987:11	15.56	4.94	.908
New Zealand	1970:2–1987:10	11.32	6.57	.748
Spain	1965:2–1987:9	23.20	8.35	.885
Sweden	1973:2–1987:10	14.19	4.50	.909
Switzerland	1960:2–1987:10	13.99	5.14	.881
United King.	1960:2–1987:11	11.40	2.25	.963
United States	1960:2–1987:12	11.03	2.83	.938
Yugoslavia	1960:2–1987:11	14.24	10.19	.662

	JAN	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
Australia	-33.77	-5.70	7.15	-.41	6.63	-7.80	2.27	.66	-1.03	4.40	2.82	24.77
Austria	-52.38	-2.66	13.54	.05	-.08	-.77	4.80	-1.46	-.47	6.81	3.08	29.53
Belgium	-27.28	-3.88	14.56	.12	.34	1.46	-11.67	-.50	7.37	3.62	-6.78	22.65
Canada	-36.61	-4.27	14.59	4.66	6.41	-1.71	-4.95	-1.99	-.89	5.57	2.49	16.70
Denmark	-30.17	-10.79	9.00	1.04	4.89	-1.86	2.48	-1.64	-4.14	4.49	-2.40	29.11
Finland	-43.50	1.22	3.54	11.27	4.97	-2.69	-8.85	-.73	2.76	2.25	:47	29.29
France	-47.02	-18.32	15.94	-2.34	4.00	-.13	-5.15	-8.67	21.62	3.18	-3.02	39.92
Germany	-42.20	-3.34	17.26	-.20	-2.21	-4.44	3.90	-7.65	3.75	11.13	3.44	20.56
Greece	-23.18	2.11	-9.24	12.38	-9.35	-2.89	-4.28	4.98	.53	7.28	1.75	19.91
Italy	-47.07	-6.65	16.36	-1.42	.30	-1.12	-2.69	-13.25	19.20	8.16	-8.36	36.53
Japan	-43.12	-3.42	17.94	-2.89	-2.48	-.39	7.85	-7.95	-2.36	4.96	.80	31.06
Netherlands	-16.19	-13.87	15.78	.84	3.79	-4.48	.48	-6.50	4.45	7.74	.01	7.97
Norway	-44.96	-2.94	9.45	1.97	6.13	3.51	-4.46	.58	-.89	6.33	-1.92	27.21
New Zealand	-31.44	.13	11.18	-2.99	6.75	-8.34	3.43	.75	-.71	.63	2.57	18.02
Spain	10.61	-54.83	.14	2.03	7.13	1.83	28.90	-34.23	4.51	18.23	-11.41	27.10
Sweden	-38.99	-6.10	10.81	3.96	1.21	-1.98	-3.50	.90	-.11	8.98	-1.99	26.79
Switzerland	-33.40	-12.79	13.53	1.28	-1.69	-3.32	-3.19	-7.54	3.32	9.56	8.36	25.89
United King.	-32.78	-3.85	4.07	1.37	.67	-.92	3.18	-3.09	.57	4.32	6.14	20.30
United States	-30.65	-3.50	13.12	1.16	3.85	-.58	-2.04	1.08	-4.44	4.42	.27	17.31
Yugoslavia	-43.59	2.74	15.76	9.24	-8.48	6.80	1.62	3.28	1.53	.61	.02	10.46

Table 3: Industrial Production, Log Growth Rates (Monthly)

	Sample Period	*Std. Dev. of Seasonals*	*Std. Dev. of Residuals*	R^2
Australia	1963:2–1987:9	12.29	2.72	.953
Austria	1960:2–1987:11	6.56	3.37	.791
Belgium	1960:2–1987:9	10.49	4.55	.841
Canada	1960:2–1987:11	5.71	2.37	.847
Finland	1960:2–1987:11	16.44	5.08	.913
France	1960:2–1987:11	17.41	4.47	.938
Germany	1960:2–1987:11	7.02	3.56	.795
Greece	1962:2–1987:10	4.38	4.35	.503
Ireland	1975:8–1987:10	8.53	3.94	.824
Italy	1960:2–1987:10	22.53	9.23	.856
Japan	1960:2–1987:11	5.30	1.95	.880
Luxembourg	1960:2–1987:9	7.84	6.23	.613
Netherlands	1960:2–1987:11	6.74	3.64	.774
Norway	1960:2–1987:11	18.13	8.18	.831
Portugal	1968:2–1987:8	9.01	6.58	.652
Spain	1961:2–1987:9	13.94	8.38	.735
Sweden	1960:2–1987:11	32.95	5.61	.972
United King.	1960:2–1987:11	6.85	2.92	.846
United States	1960:2–1987:12	2.45	1.17	.813
Yugoslavia	1960:2–1987:11	9.00	3.37	.877

	JAN	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
Australia	-21.41	33.47	-.16	-3.00	.19	-.59	1.44	.28	2.83	-.18	1.64	-14.50
Austria	-13.12	5.32	2.13	1.78	2.80	.18	-13.22	.57	10.00	2.36	3.80	-2.59
Belgium	-1.29	5.90	.24	1.70	-.65	-.84	-27.11	17.67	10.78	.05	3.07	-9.50
Canada	.07	6.72	-.40	-1.72	-.65	3.38	-13.70	4.36	7.78	.01	1.79	-7.66
Finland	-.03	1.29	-.07	2.29	-.46	-5.61	-41.79	36.99	6.96	1.68	1.63	-2.89
France	-.51	1.77	-.39	-.55	-2.84	1.68	-12.12	-36.54	45.68	3.76	1.83	-1.76
Germany	-8.62	6.32	1.50	1.88	-1.18	.61	-11.79	-4.58	15.84	1.74	4.29	-5.99
Greece	-7.19	4.93	2.30	-.69	1.96	4.76	-1.75	-3.46	8.50	-4.69	-1.55	-3.13
Ireland	-3.61	7.87	3.94	-.49	1.70	3.44	-9.84	-13.96	18.86	-.55	1.81	-9.16
Italy	1.46	4.37	.66	.25	.49	-.29	-4.30	-52.17	56.58	-1.04	1.48	-7.48
Japan	-10.88	5.78	7.93	-5.56	-2.21	3.27	.44	-5.91	5.84	-.60	-.67	2.57
Luxembourg	.26	4.98	.45	2.39	1.91	-.70	-6.02	-16.56	18.50	-.53	1.45	-6.12
Netherlands	-5.75	2.51	-.64	-.63	-3.62	-1.00	-17.11	5.59	10.28	6.64	3.74	-.01
Norway	4.61	5.74	-4.41	-6.69	-2.09	8.40	-44.76	38.75	7.64	2.33	2.64	-12.17
Portugal	-1.16	2.48	1.46	.97	-2.64	.55	-4.92	-19.23	23.62	1.72	-.34	-2.50
Spain	-.43	-.78	4.01	-3.33	2.83	-2.05	-2.68	-32.74	33.97	4.16	-.24	-2.72
Sweden	-4.38	1.60	1.17	5.05	-2.38	1.13	-84.48	75.17	6.65	2.95	1.34	-3.81
United King.	.24	6.27	1.42	-7.09	.92	.24	-9.40	-5.80	16.09	2.97	2.55	-8.42
United States	.15	2.60	.27	-.39	.11	2.35	-5.19	3.42	2.36	-.35	-2.22	-3.10
Yugoslavia	-17.29	4.30	10.82	-3.32	-1.22	2.89	-17.07	9.21	7.30	4.00	-5.71	6.09

Table 4: Money Stock, Log Growth Rates (Monthly)

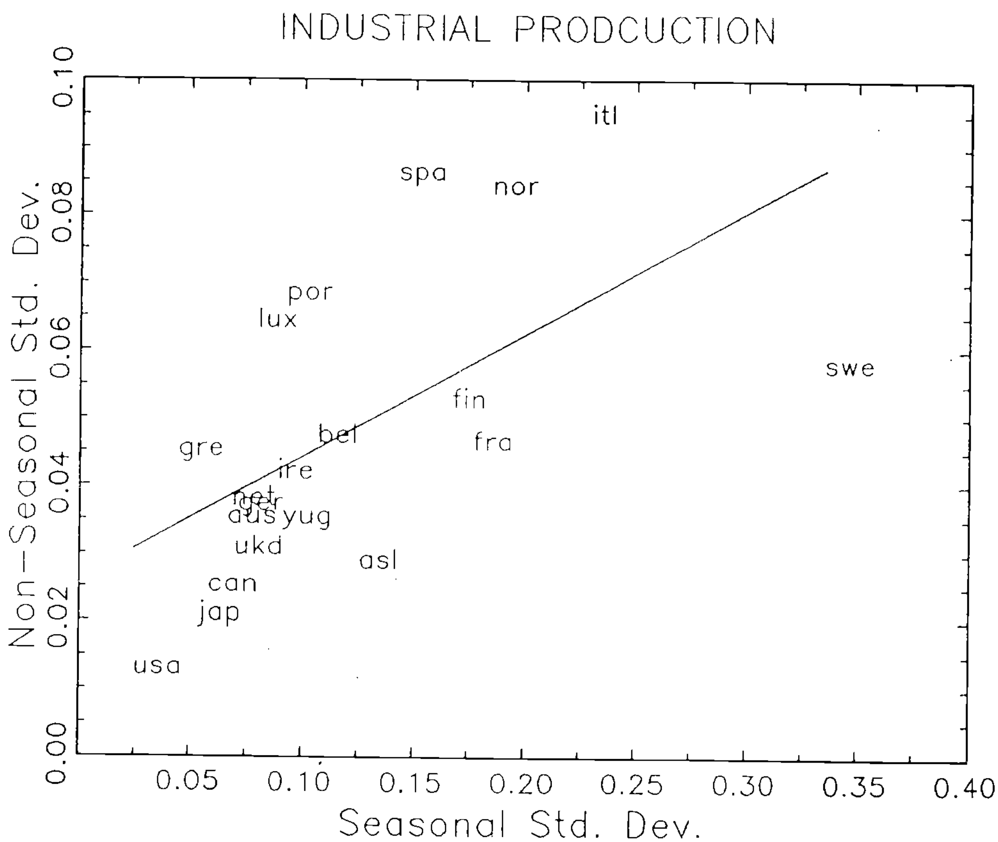
	Sample Period	*Std. Dev. of Seasonals*	*Std. Dev. of Residuals*	R^2
Australia	1960:7 –1987:11	1.64	1.23	.638
Austria	1960:2 –1987:11	2.16	1.94	.554
Belgium	1976:1 –1987:12	2.31	1.31	.757
Canada	1960:2 –1987:12	1.96	1.50	.631
Denmark	1970:3 –1987:11	4.26	2.99	.671
Finland	1960:2 –1987:11	2.53	3.39	.358
France	1970:1 –1987:11	2.65	1.61	.731
Germany	1960:2 –1987:12	2.76	1.26	.827
Greece	1960:2 –1987:10	3.73	2.91	.622
Iceland	1960:2 –1987:10	2.20	4.46	.195
Ireland	1976:11–1987:12	2.91	1.81	.721
Italy	1962:1 –1987:11	2.35	1.77	.638
Japan	1960:2 –1987:11	3.90	1.57	.859
Netherlands	1960:2 –1987:10	1.77	1.58	.557
Norway	1966:2 –1987:10	2.23	1.96	.566
New Zealand	1977:4 –1987:10	4.51	3.09	.680
Spain	1960:2 –1987:11	3.31	1.17	.890
Switzerland	1960:2 –1987:11	1.74	1.41	.604
Taiwan	1968:2 –1987:12	3.60	3.17	.563
Turkey	1977:1 –1987:12	5.74	5.07	.562
United King.	1971:7 –1987:12	1.31	1.82	.340
United States	1960:2 –1987:12	1.47	.61	.852
Yugoslavia	1964:11–1987:10	1.02	2.47	.147

	JAN	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
Australia	-.79	-.33	.01	-.81	-3.28	-.26	-.92	-.47	.58	1.35	.92	4.01
Austria	-3.78	.69	-.41	.97	1.18	1.80	-.26	.49	1.16	-4.42	3.64	-1.06
Belgium	-1.54	-2.39	1.77	1.63	1.35	3.46	-4.25	-2.25	.71	-1.56	-.10	3.18
Canada	-3.97	-3.17	.03	1.42	.22	1.28	1.43	-.47	.30	.15	-.90	3.67
Denmark	-9.37	-1.11	3.52	1.10	-.67	5.64	-6.73	-1.38	3.09	.00	.56	5.35
Finland	-4.55	-.97	-.76	.54	1.27	1.65	-2.67	-.45	.48	-1.73	.83	6.37
France	-3.98	-1.94	1.26	.31	-1.17	2.31	.52	-3.28	-1.45	.26	-2.08	6.32
Germany	-7.51	.05	-.34	.74	1.27	1.16	-.36	-.64	-.42	-.25	5.59	.71
Greece	-8.21	-1.38	-1.35	4.17	-2.71	1.97	1.34	.69	.38	-1.22	-1.65	7.97
Iceland	-1.80	-.48	2.47	4.17	2.50	-1.85	.72	-3.40	-.57	.83	.22	-2.83
Ireland	-5.36	-3.51	2.84	-1.92	-.44	2.65	-1.21	.98	2.29	-2.04	.43	5.30
Italy	-4.05	-1.79	-.03	-.12	-.26	.28	.31	-1.67	.64	.04	-.05	6.68
Japan	-7.57	-2.67	4.00	.29	-.99	.84	-1.69	-2.25	1.26	-2.01	1.58	9.22
Netherlands	-.41	-.75	.80	2.09	4.38	-.12	-2.00	-2.44	-.47	-1.38	.44	-.11
Norway	-.48	-2.35	-2.25	-.02	-1.63	4.90	-.41	-1.70	.89	2.22	-2.13	2.97
New Zealand	-7.88	5.59	-6.40	2.77	-.27	-1.31	-1.33	1.93	-5.24	1.87	2.08	8.19
Spain	-7.51	-1.20	.75	-.20	-.45	2.18	1.40	-2.73	1.02	-.75	-.26	7.76
Switzerland	-3.44	-1.66	1.16	-.46	-.45	.79	-2.13	-.79	1.67	.90	1.34	3.07
Taiwan	3.43	-6.36	-3.53	-.59	.95	4.42	-4.28	.33	-.84	-.04	-.57	7.08
Turkey	-13.62	-1.89	-1.44	1.11	-.12	-.13	2.38	1.91	-1.78	1.95	-1.81	13.44
United King.	-3.51	-1.03	1.32	1.71	-.07	.10	.88	-.93	-.11	.13	.74	.77
United States	-.71	-3.23	.08	1.91	-2.20	1.08	.39	-.79	.49	.46	.69	1.84
Yugoslavia	.53	-.99	-.83	.59	-.90	-1.00	2.50	1.05	-1.39	-.29	-.25	.08

Table 5: Consumer Price Index, Log Growth Rates (Monthly)

	Sample Period	*Std. Dev. of Seasonals*	*Std. Dev. of Residuals*	R^2
Austria	1960:2–1987:12	.32	.57	.239
Belgium	1960:2–1987:12	.10	.38	.060
Canada	1960:2–1987:12	.12	.38	.087
Denmark	1967:2–1987:12	.25	.66	.122
Finland	1960:2–1987:12	.23	.97	.052
France	1960:2–1987:12	.09	.38	.051
Germany	1960:2–1987:12	.21	.29	.345
Greece	1960:2–1987:12	.99	.99	.500
Italy	1960:2–1987:11	.15	.59	.060
Japan	1960:2–1987:12	.51	.69	.357
Luxembourg	1960:2–1987:12	.10	.44	.048
Netherlands	1960:2–1987:12	.35	.61	.246
Norway	1960:2–1987:12	.41	.80	.213
Portugal	1960:2–1987:10	.53	1.44	.119
Spain	1960:2–1987:12	.22	.76	.078
Sweden	1960:2–1987:12	.22	.90	.054
Switzerland	1960:2–1987:12	.17	.38	.164
Turkey	1969:5–1987:12	1.56	3.29	.184
United King.	1962:2–1987:12	.35	.61	.246
United States	1960:2–1987:12	.07	.35	.036
Yugoslavia	1960:2–1987:12	.85	3.19	.066

	JAN	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
Austria	.58	-.02	-.06	.05	-.07	.72	-.32	-.35	-.35	-.12	-.03	-.03
Belgium	.21	.07	-.14	.02	-.04	-.00	.11	-.15	.06	-.04	-.05	-.05
Canada	-.06	-.02	.04	.01	.04	.18	.18	-.05	-.30	.00	.04	-.08
Denmark	-.29	-.16	.20	.13	.45	-.18	.08	-.18	.22	-.01	.20	-.45
Finland	.50	.04	.08	.27	.00	.09	-.01	-.28	.00	-.09	-.23	-.38
France	.17	-.08	.01	.07	-.02	-.06	.07	-.07	.01	.11	-.05	-.16
Germany	.52	.06	-.00	.04	.03	.03	-.18	-.43	-.18	-.03	.10	.04
Greece	.07	-1.29	1.35	.53	-.30	-.28	-1.39	-1.63	1.45	.84	.04	.61
Italy	.14	.15	-.07	.00	-.01	-.25	-.25	-.14	.12	.21	.14	-.03
Japan	.56	-.20	.07	.62	-.09	-.60	-.32	-.35	.95	.33	-.90	-.05
Luxembourg	.11	.04	-.23	.05	.11	-.00	.01	-.17	.01	-.01	.03	.04
Netherlands	.17	.21	.23	.73	-.40	-.25	-.57	.03	.38	-.03	-.25	-.25
Norway	1.02	-.11	.34	-.32	-.21	.01	.48	-.57	.11	-.18	-.19	-.38
Portugal	.19	.19	.80	-.31	-1.13	-.83	-.29	.41	.46	.21	.14	.17
Spain	.27	-.40	.09	.15	-.12	-.49	.15	.08	-.01	-.02	.16	.12
Sweden	.55	.24	-.15	.09	-.30	.04	-.13	.10	-.05	-.09	-.18	-.12
Switzerland	.07	-.05	-.11	-.21	.24	.04	-.20	.05	-.09	-.03	.39	-.10
Turkey	2.04	.12	1.53	1.29	.64	-3.76	.34	-1.18	1.12	.29	-.70	-1.71
United King.	.14	-.05	-.04	1.06	-.08	-.06	-.34	-.32	-.28	.08	.00	-.10
United States	-.07	.06	-.01	.08	.03	.10	.07	-.05	.04	-.06	-.09	-.09
Yugoslavia	1.15	-.08	-.02	-.35	.04	.09	-1.82	-1.15	.12	1.08	1.13	-.17


INDUSTRIAL PRODCUCTION
Non-Seasonal Std. Dev.
Seasonal Std. Dev.
0.00
0.02
0.04
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0.05
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itl
spa
nor
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lux
swe
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bel
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fra
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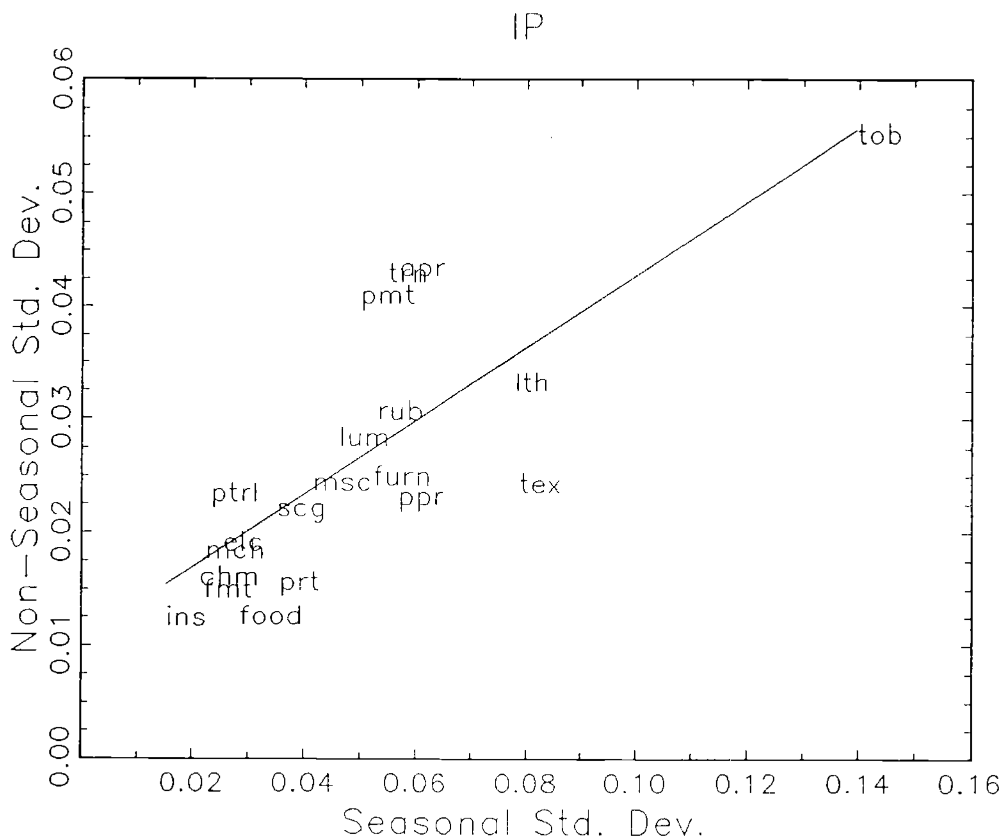
net
aus
yug
ukd
asl
can
jap
usa

Figure 1


IP
tob
tppr
trn
pmt
lth
rub
lum
mscfurn
tex
ptrl
ppr
scg
elc
mch
chm
fmt
prt
ins
food
0.00
0.01
0.02
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0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
Non-Seasonal Std. Dev.
Seasonal Std. Dev.

Figure 2