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Interactions Between the Seasonal and Business Cycles in Production and Inventories

By Stephen G. Cecchetti, Anil K Kashyap, and David W. Wilcox

This paper shows that in several U.S. manufacturing industries, the seasonal variability of production and inventories varies with the state of the business cycle. We present a simple model which implies that if firms reduce the seasonal variability of their production as the economy strengthens, and they either hold constant or increase the stock of inventories they bring into the high-production seasons of the year, then they must be facing upward-sloping and convex marginal cost curves. We conclude that firms in a number of industries face upward-sloping and convex marginal-production-cost curves. (JEL E32, C49)

A growing literature examines the shape of the aggregate production function. Recently, the orthodox view that marginal cost curves are upward-sloping and convex has been attacked by Robert E. Hall (1991) and Valerie A. Ramey (1991), who argue that a number of important macroeconomic phenomena are consistent with declining marginal costs, i.e., increasing returns to scale or agglomeration economies. This paper develops new evidence on the shape of marginal-production-cost curves based on changes in the seasonal patterns of production and inventory holdings over the business cycle.

The intuition for our analysis is that capacity constraints are most likely to bind when both the business cycle is at its peak and production is seasonally high. During a boom, the presence of a capacity constraint might cause firms to reorganize the pattern of their production within the year in order to produce a larger fraction of annual output in off-peak seasons, thereby avoiding the high marginal cost (in the extreme case, the infinitely high marginal cost) associated with additional production during the normally busy periods of the year.

This intuition is incomplete because the change in the seasonal pattern of production over the business cycle generally will not be sufficient to reveal the shape of firms’ cost functions. However, in the next section of the paper we show how information on the interaction between seasonal and business cycles can be combined with data on inventories to identify the shape of firms’ cost functions. If, as the economy strengthens, firms both reduce the seasonal variability of production and carry more inventories into the high-production season, we can conclude that firms face an upward-sloping and convex marginal-production-cost curve.

We conduct the empirical aspect of our investigation using data for each of the 20 two-digit manufacturing industries in the United States. For all but one industry, we find overwhelming evidence that the seasonal patterns of both production and inventories change
over the business cycle. These are the "inter-
actions" referred to in the title. In a number
of these industries, these interactions are of
such a nature as to allow us to determine the
shape of the marginal-production-cost curve
faced by the representative firm in the indus-
try. In five industries, booms are associated
with a reduction in the seasonal amplitude of
production and either no change or an increase
in inventory holdings coming into the high-
production season; on the basis of this infor-
mation, we conclude that firms in these
industries face upward-sloping and convex
marginal-production-cost curves. In one other
industry we find that booms are associated
with an increase in the seasonal variability of
production and a reduction in the level of in-
ventories brought into the high-production
seasons; on the basis of this information, we
conclude that firms in that industry face
marginal-production-cost curves that flatten
out, and hence have an incentive to bunch their
production. Unfortunately, in the other 14
industries, the nature of the interactions we de-
tect does not allow us to identify the shapes of
the marginal-production-cost curves.

This work builds on that of Jeffrey A. Miron
and Stephen P. Zeldes (1988, 1989), Robert
B. Barsky and Miron (1989), J. Joseph
Beaulieu and Miron (1991, 1992), and
Spencer D. Krane (1993), all of whom use
information on seasonal cycles to provide in-
sights into economic behavior; Olivier J.
Blanchard (1983), Kenneth D. West (1986),
Ray C. Fair (1989), Krane and Steven N.
Braun (1991), and Kashyap and Wilcox
(1993), who analyze the cost structure of pro-
duction; Eric Ghysels (1991), who documents
the statistical asymmetries in seasonal fluctua-
tions; and Alan S. Blinder (1986) and
Blinder and Louis J. Maccini (1991), who
study inventories and production smoothing.1
Our work is closest to that of Beaulieu et al.
(1992), who show that the amplitude of sea-
sonal cycles is positively correlated with the
amplitude of business cycles, both across in-
dustries and across countries. We view their
finding as complementary to ours. An impor-
tant distinguishing feature of our effort is that
by jointly analyzing production and inventory
data we are able to establish the conditions un-
der which any interactions between cyclical
and seasonal variation can be used to learn
about the shape of industry cost curves.

The remainder of this paper is organized as
follows: Section I outlines the circumstances
under which we will be able to deliver
evidence on the shape of the marginal-
production-cost function. Section II presents
our empirical results, and Section III contains
our conclusions.

I. A Simple Model

This section outlines the circumstances
under which a change over the business
cycle in the seasonal amplitude of produc-
tion reveals information about the shape
of the marginal-production-cost function.
Marginal-production-cost schedules can
take on any of four generic shapes. The first
shape is upward-sloping and convex. Firms
facing this type of curve have an incentive
to smooth production. We refer to these
firms as facing capacity constraints. The sec-
ond generic shape is either upward-sloping
and concave, or downward-sloping and con-
 vex. In either case, the first derivative of the
cost curve is a decreasing function of the
level of production (the curve "flattens out"). Firms facing this type of curve have
an incentive to bunch production. The third
shape is linear. This type of curve gives no
incentive either to smooth production or to
bunch it, regardless of whether the curve is
upward-sloping, flat, or downward-sloping.
Finally, there are marginal curves that are
downward-sloping and concave. These
curves encourage bunching, but we dismiss
them from further consideration because
they generally will not give rise to interior
solutions to the cost-minimization problem
unless the inventory-holding-cost function is
sufficiently convex.2 Thus, our task is to de-
velop a technique for distinguishing among
three marginal-production-cost curves: (1)

1 West's (1990) work using inventory fluctuations to
distinguish supply from demand shocks is also related.

2 In cases where the holding-cost function is suffi-
ciently convex to guarantee an interior optimum, the cur-
vature of the holding-cost function will force the firm to
behave as if it is capacity constrained.
capacity constrained, (2) flattening out, and
(3) linear.

We illustrate our method using a simple two-
period model. Together, the two periods in the
model span one seasonal cycle. The represen-
tative firm chooses its productive capacity prior
to the start of the first period. Once this choice
has been made, the state of the business cycle is
revealed; both capacity and the state of the busi-
ness cycle remain fixed for the rest of time. As
a harmless normalization, we assume that pro-
duction is higher in the second period than in the
first. We ignore discounting.

There are two key building blocks for our
analysis. One is the requirement that the firm
allocate its production between the first and
second periods so that the expected marginal
cost of producing an extra unit of output in the
first period and storing it until the second per-
iod equals the expected marginal cost of pro-
ducing an extra unit in the second period.
Stated in slightly different terms, optimal pro-
duction scheduling requires that the difference
between marginal production costs in the sea-
sons must equal the marginal cost of holding
inventories across the two seasons. We
emphasize that this requirement must hold irre-
spective of whether the shocks in the model
originate from the cost side of the model or the
demand side. The second building block is the
assumption that the holding-cost function is
convex in the level of inventories.

In many circumstances we will be able to
describe the marginal-production-cost curve if
we are allowed to observe two pieces of infor-
mation: the change over the business cycle in
the seasonal amplitude of production and the
change over the business cycle in the level of
inventories that firms carry into the high-
production (second) season. For example, sup-
pose the volume of inventories brought into the
second period is an increasing function of the
strength of the economy, and the amplitude of
the seasonal variation in production is either a
decreasing function of, or invariant with respect
to, the same variable. Then we can conclude
that the firm must be facing a capacity-
constraint-type marginal-production-cost func-
tion. How so? Given the assumed convexity of
the holding-cost function, the positive correla-
tion between the state of the business cycle and
the level of inventories carried into the second
period implies that the difference between sec-
ond- and first-period marginal production
costs must increase as the economy strengthens.
A greater difference between marginal produc-
tion costs in the two periods can be consistent
with a diminished or unchanged difference in
the quantity produced in the two periods only
if the marginal-production-cost function is of
the capacity-constraint type. We catalogue this
result in the middle and lower blocks of the
right-hand column in Table 1. Similar reason-
ing can be used to derive the other entries
shown in the table.

Unfortunately, in two cases—when the
level of inventories carried into the busy sea-
son and the seasonal amplitude of production
move in the same direction over the business
cycle—we cannot make any inference about
the shape of the marginal-production-cost curve: The marginal-production-cost function
could be any of the three shapes.

Thus, in the context of a two-period model,
the results derived in this section constitute a
(nearly) complete guide to the identification
of the curvature of the marginal-production-
cost function based on two pieces of infor-
mation: the change in the seasonal amplitude
of production over the business cycle, and the
change in the seasonal pattern of inventory
holdings over the business cycle. Unfortuna-
tely, there is no guarantee that this guide
will be as exhaustive once adapted for use with
12 seasons rather than just two. For example,
the seasonal pattern of production may change
over the business cycle, but not in a way that
we can easily characterize as smoothing or
bunching. Or, the seasonal pattern of inventory
holdings may change over the business cycle,
but not in a way that is correlated with the
seasonal pattern of production. As a result,
there is the possibility (which turns out to be
realized) that the apparent clarity of the two-
period results are muddied a bit once applied
to monthly data.

3 A first-order condition of this type falls out of all stan-
dard production-scheduling problems. See, inter alia,
Charles F. Holt et al. (1960), West (1986), Ramey
4 Our assumption in this regard is consistent with the
long line of models descended from Holt et al. (1960). In
such models, the quadratic term in the level of inventories
causes inventories to be cointegrated with sales, provided
a certain cost shock is stationary.
TABLE 1—Given the change in the seasonal amplitude of production and the change in inventory holdings over the business cycle, is the marginal-production-cost function best described as linear, flattening out, or exhibiting capacity constraints?

<table>
<thead>
<tr>
<th>During a boom, does the seasonal amplitude of production increase, stay the same, or decrease?</th>
<th>Less</th>
<th>Same amount</th>
<th>More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase</td>
<td>Flattening out</td>
<td>Flattening out</td>
<td>Could be any of the three</td>
</tr>
<tr>
<td>Stay the same</td>
<td>Flattening out</td>
<td>Linear</td>
<td>Capacity constrained</td>
</tr>
<tr>
<td>Decrease</td>
<td>Could be any of the three</td>
<td>Capacity constrained</td>
<td>Capacity constrained</td>
</tr>
</tbody>
</table>

II. Empirical Results

The objectives of this section are (1) to quantify the interactions between seasonal and cyclical influences on production at the two-digit level in the manufacturing sector, and (2) to examine simultaneously data on production and inventories for clues as to the shape of the marginal-production-cost function.

A. Evidence on Seasonal and Cyclical Interactions in Production

Consider the following reduced-form expression for monthly production:

\[ \ln Q_t - \ln \bar{Q}_t = \sum_{i=1}^{12} s_{it} f_i(\lambda_t), \]

where the \( s_{it} \)'s are conventional seasonal dummy variables (\( s_{it} = 1 \) if month \( t \) is the \( i \)th month of the year, 0 otherwise), \( \lambda_t \) is a stationary variable indicating the stage of the business cycle, \( f_i(.) \) is differentiable, and \( \ln Q_t \) is the level of production that would prevail in the average season if the cycle were at a neutral position.

Substituting a linear expansion of the functions \( f_i, f_i(\lambda_t) \approx \sigma_i + \phi_i \lambda_t \), into (1), we have

\[ \ln Q_t - \ln \bar{Q}_t = \sum_{i=1}^{12} \sigma_i s_{it} + \sum_{i=1}^{12} \phi_i s_{it} \lambda_t. \]

The coefficients \( \phi_i \) determine the interaction between the seasonal and cyclical influences on production.

Following William R. Bell and Steven C. Hillmer (1984), we rewrite (2) as

\[ \ln Q_t - \ln \bar{Q}_t = \sigma + \bar{\phi} \lambda_t + \sum_{i=1}^{11} (\sigma_i - \bar{\sigma})(s_{it} - s_{12t}) \]

\[ + \sum_{i=1}^{11} (\phi_i - \bar{\phi})(s_{it} - s_{12t}) \lambda_t, \]

where \( \bar{\sigma} \) and \( \bar{\phi} \) are the means of the \( \sigma_i \)'s and \( \phi_i \)'s, respectively. The conventional assumption is that \( \phi_i = \phi \), in which case the deviation of production from its normal value is a function only of the stage of the business cycle and seasonal dummies.

One possible interpretation of \( \ln Q_t \) is as a combination of a linear trend and a (presumably nonstationary) variable \( \nu_t \). This leads us to difference (3), so that

\[ \Delta \ln Q_t = \alpha + \bar{\phi} \Delta \lambda_t + \sum_{i=1}^{11} \Delta \{ [(\sigma_i - \bar{\sigma}) \]

\[ + (\phi_i - \bar{\phi}) \lambda_t]} (s_{it} - s_{12t}) \} + \Delta \nu_t, \]

where \( \alpha \) is the slope of the linear trend in \( \ln Q_t \).
We estimate equation (4) using monthly data on production at the two-digit level, constructed from Commerce Department estimates of shipments and inventories following the procedures outlined in Douglas Holtz-Eakin and Blinder (1983), West (1983), Patricia Reagan and Dennis P. Sheehan (1985), and Miron and Zeldes (1989). We updated the data used by these authors in two respects. First, of course, we included additional observations not previously available. Second, we recomputed the (separate) markup factors required to convert inventories at the finished-goods and work-in-process levels from a "cost" basis to a "market" basis. Previous authors (Holtz-Eakin and Blinder, 1983; West, 1983) computed markup factors for 1972, which was the base year as of their writing; we computed (and used in constructing our updated measures of output) factors for 1987, which is the base year as of our writing.

For each industry except electronic equipment and instruments, the sample period runs from March 1967 through March 1995. (Using data that begin in January 1967, we computed output as shipments plus the change in inventories, accounting for one lost observation at the front of the sample period, and then computed the log change in production, accounting for the other lost observation.) For electronic equipment and instruments, we end the sample period in December 1986 to avoid a discontinuity in the data resulting from the reclassification of certain four-digit industries from electronic equipment to instruments. The regression for transportation equipment includes dummy variables for September through December of 1970 to control for the influence of the auto strike. We estimate the covariance matrix of the coefficient estimates using the Whitney K. Newey and West (1987) procedure with 24 lags, and we define $\lambda_i$ to be the one-month lag of capacity utilization in total manufacturing.\footnote{Prior to estimating equation (4), we removed the seasonal means from capacity utilization in order to guarantee that our estimated coefficients reflect information solely about production and not also about capacity utilization.}

We begin by testing whether the interaction coefficients $\{\phi_i - \bar{\phi}\}$ are jointly significant. To this end, we define the variable $\phi = (\phi_1 - \bar{\phi}, ..., \phi_{11} - \bar{\phi})$, and test the hypothesis $H_0: \phi = 0$ against $H_a: \phi \neq 0$. Columns (2) and (7) of Table 2 present our results. For every industry except tobacco (SIC 21), we reject the null hypothesis overwhelmingly. Thus, interactions of some type between the business cycle and the seasonal pattern of production appear to be nearly ubiquitous.\footnote{We also note that these series are very seasonal. In 16 of the 20 cases, seasonal dummy variables explain over 50 percent of the variation in the data, implying that the interactions could lead to important shifts in the overall variability of production.}

We next investigate the nature of the changes in the seasonal pattern of production over the business cycle, focusing specifically on whether the seasonal variability of production generally increases or decreases as the economy strengthens. The magnitude of the overall seasonal for month $i$ is related to $D_i(\lambda) = [(\sigma_i - \bar{\sigma}) + (\phi_i - \bar{\phi})\lambda_i]^2$. We summarize the behavior of all 12 $D_i$'s over the business cycle by constructing the following ratio $\bar{R} = \frac{\sum_{i=1}^{12} D_i(\lambda)}{\sum_{i=1}^{12} D_i(\lambda_{50})}$ where $\lambda_{50}$ and $\lambda_i$ are, respectively, the means of all recorded values of $\lambda$ above the 85th percentile and below the 15th percentile of $\lambda$. If the seasonal variability of production tends to shrink as the economy strengthens, $\bar{R}$ will be less than 1. Columns (3) and (8) of Table 2 show our estimates of $\bar{R}$ and, in brackets, the $p$-values for the tests that $\bar{R}$ equals 1. (We executed these tests using the delta method.) For 15 of the 20 two-digit manufacturing industries, the point estimate of $\bar{R}$ is less than 1. In six of these cases, the discrepancy from 1 is statistically significant at the 7-percent level or better.\footnote{We also reestimated equation (4) using lagged own-industry capacity utilization as the proxy for $\lambda$, and instrumenting for own-industry capacity using aggregate manufacturing capacity utilization. This procedure yielded very similar results to those shown in Table 2.} In no case is $\bar{R}$ significantly greater than 1 at anything better than the 20-percent level.

B. Evidence on the Curvature of the Marginal-Production-Cost Function

In line with our objective of identifying the shape of the marginal-production-cost function, we now consider the joint behavior of...


<table>
<thead>
<tr>
<th>(1) Industry</th>
<th>(2) $p$-value</th>
<th>(3)</th>
<th>(4)</th>
<th>(5) Implied type of marginal-production-cost curve</th>
<th>(6) Industry</th>
<th>(7) $p$-value</th>
<th>(8)</th>
<th>(9)</th>
<th>(10) Implied type of marginal-production-cost curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Food</td>
<td>0.00</td>
<td>0.69</td>
<td>-0.10</td>
<td>[0.15]</td>
<td>30 Rubber</td>
<td>0.00</td>
<td>1.08</td>
<td>-0.02</td>
<td>[0.76]</td>
</tr>
<tr>
<td>21 Tobacco</td>
<td>0.50</td>
<td>0.45</td>
<td>-0.57</td>
<td>[0.04]</td>
<td>31 Leather</td>
<td>0.00</td>
<td>1.04</td>
<td>-0.09</td>
<td>[0.90]</td>
</tr>
<tr>
<td>22 Textiles</td>
<td>0.00</td>
<td>0.82</td>
<td>0.19</td>
<td>[0.14]</td>
<td>32 Stone, clay, and glass</td>
<td>0.02</td>
<td>0.89</td>
<td>0.37</td>
<td>[0.58]</td>
</tr>
<tr>
<td>23 Apparel</td>
<td>0.00</td>
<td>0.82</td>
<td>-0.15</td>
<td>[0.26]</td>
<td>33 Primary metals</td>
<td>0.00</td>
<td>0.42</td>
<td>0.32</td>
<td>[0.00]</td>
</tr>
<tr>
<td>24 Lumber</td>
<td>0.01</td>
<td>0.48</td>
<td>-0.60</td>
<td>[0.00]</td>
<td>34 Fabricated metals</td>
<td>0.00</td>
<td>0.70</td>
<td>-0.07</td>
<td>[0.07]</td>
</tr>
<tr>
<td>25 Furniture</td>
<td>0.00</td>
<td>0.94</td>
<td>0.05</td>
<td>[0.81]</td>
<td>35 Industrial machinery</td>
<td>0.00</td>
<td>0.87</td>
<td>0.22</td>
<td>[0.16]</td>
</tr>
<tr>
<td>26 Paper</td>
<td>0.00</td>
<td>0.64</td>
<td>0.34</td>
<td>[0.19]</td>
<td>36 Electronic equipment</td>
<td>0.00</td>
<td>0.96</td>
<td>0.25</td>
<td>[0.82]</td>
</tr>
<tr>
<td>27 Printing</td>
<td>0.00</td>
<td>1.67</td>
<td>-0.01</td>
<td>[0.35]</td>
<td>37 Transportation</td>
<td>0.00</td>
<td>1.03</td>
<td>-0.10</td>
<td>[0.90]</td>
</tr>
<tr>
<td>28 Chemicals</td>
<td>0.00</td>
<td>0.49</td>
<td>0.62</td>
<td>[0.00]</td>
<td>38 Instruments</td>
<td>0.01</td>
<td>1.84</td>
<td>-0.22</td>
<td>[0.20]</td>
</tr>
<tr>
<td>29 Petroleum</td>
<td>0.00</td>
<td>0.15</td>
<td>0.28</td>
<td>[0.00]</td>
<td>39 Miscellaneous durable goods</td>
<td>0.00</td>
<td>0.73</td>
<td>-0.44</td>
<td>[0.28]</td>
</tr>
</tbody>
</table>

**Notes:** Results are calculated from the estimation of equations (4) and (5). Columns (2) and (7) refer to the test that there is no interaction between the season and the cycle in production. Columns (3) and (8) report the variable $\%$, defined as the sum of squared total seasonal factors at a relatively high point in the business cycle, divided by the sum of squared seasonals at a relatively low point. In parentheses, we report the $p$-value for the test $H_0: \% = 1$. Columns (4) and (9) report the correlation $\rho$ of $(\omega - \bar{\omega})$ in equation (5) with $(\sigma_{i+1} - \bar{\sigma})$ in equation (4), when the two are estimated jointly. The number in brackets in columns (4) and (9) is the $p$-value for the test $H_0: \rho = 0$. Columns (5) and (10) report the implied curvature of the marginal-production-cost function based on the estimates in the other columns and the categorization developed in Section I.

Production and inventories. To that end, we introduce the analogue for inventories to the specification we examined earlier for production:

\[
\Delta \ln I_t = \gamma + \bar{\omega}\Delta \lambda_t + \sum_{i=1}^{11} \Delta \{ (\beta_i - \bar{\beta}) + (\omega_i - \bar{\omega})\lambda_t \} (s_{it} - s_{12t}) + \Delta \epsilon_t,
\]

The coefficients $(\omega_i - \bar{\omega})$ measure the extent to which inventory seasonals are influenced by the business cycle. We develop evidence on the changes over the business cycle in the seasonal pattern of inventory holdings—and the alignment of those changes with respect to the seasonal pattern in production—by stacking equations (4) and (5) and calculating the correlation between the inventory interaction coefficient $(\omega_i - \bar{\omega})$ and the production seasonal in the following month $(\sigma_{i+1} - \bar{\sigma})$. A positive value of this correlation indicates that, as the overall economy strengthens, firms tend to increase the stock of inventories they bring into the high-production seasons of the year.

The estimated values of this correlation are reported in columns (4) and (9) of Table 2.
under the heading "ρ." One of the 20 correlations (the one for chemicals) is significantly positive, while two correlations (tobacco and miscellaneous durable goods) are significantly negative. For the remaining 17 industries, the correlation is not statistically different from zero at anything better than the 10-percent level. (Separately, we tested the hypothesis that the ω's are all zero, and rejected this hypothesis at better than the 1-percent level for all 20 industries.)

Finally, we use the information reported in Table 2 to classify industries according to the framework laid out in Table 1. We summarize this classification in columns (5) and (10) of Table 2. For five industries, namely lumber, chemicals, petroleum, primary metals, and fabricated metals, the evidence is consistent with capacity-constraint-type marginal-production-cost curves. In these industries, either the seasonal amplitude of production declines as the economy strengthens, or firms bring a larger stock of inventories into the high-production seasons of the year the stronger is the overall economy, or both. The only industry for which we have solid evidence of marginal-production-cost curves that flatten out is the miscellaneous durable goods category. In this industry, the seasonal amplitude of production does not vary significantly over the business cycle, and the level of inventories brought into the busy seasons of the year is a decreasing function of the strength of the economy.

In one industry—tobacco—the evidence is inconclusive because the seasonal amplitude of production declines and inventories brought into the busy seasons vary counter cyclically. This case is further complicated by the fact that we cannot reject the null hypothesis that $R = 1$.

Unfortunately, we are unable to classify any of the remaining 13 industries. The ambiguity arises because we cannot reject either the null of constant seasonal variability over the business cycle of production ($R = 1$) or the null of no correlation between the inventory interaction and the production seasonal ($ρ = 0$). Nevertheless, we are quite confident (given our rejection of the null that the production interactions are all zero) that the marginal cost curves are not linear. Evidently, the nature of this nonlinearity is not classifiable using our framework, and we leave the relevant entries in columns (5) and (10) blank.

III. Conclusion

This paper examines recent data for the 20 two-digit manufacturing industries in the United States, and documents the following facts. First, there is a pervasive tendency for the seasonal pattern of production to vary with the state of the business cycle. Second, in five manufacturing industries, the seasonal amplitude of production is a decreasing function of the strength of the economy; in one of these industries, the level of inventories brought into the normally high-production season is an increasing function of the strength of the economy. Following the typology presented in Section I, we conclude that the representative firm in all five of these industries faces a marginal-production-cost curve that is upward-sloping and convex—an operational definition, in our view, of a capacity constraint. In one industry (the so-called miscellaneous durable goods industry), the level of inventories brought into the high-production season of the year is a decreasing function of the strength of the economy. Such behavior may mean that marginal-production-cost curves are either upward-sloping and concave, or downward-sloping and convex. In either case, firms would have the incentive to bunch production rather than smooth it. The remaining 14 industries defy easy classification: In all cases but one, we reject the hypothesis of no interaction between seasonal and cyclical influences on production; that is, the marginal-production-cost schedule appears to be nonlinear in those two factors. However, the nonlinearity does not

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8 We investigated the robustness of our classifications with respect to various splits of the sample period. We reestimated our results over the following subperiods: 67:3–80:12, 81:1–95:2, and 71:1–85:12. We found no instances in which an industry classification based on data for the full sample period was contradicted by results for one of the subperiods. There were several instances in which industries that had defied classification over the full sample were classifiable over one or more of the subperiods. For example, the textile industry was not classifiable over the full period but showed evidence of upward-sloping and convex marginal cost curves over the 81:1–95:2 and 71:1–85:12 periods.
give rise to either a marked change in the overall seasonal variability of production, or a change in the pattern of inventory holdings that is systematically related to the pattern of production. As a result, we are unable to classify these industries within the framework laid out in a simple two-period model.

Aside from their implications for the shape of the marginal cost curve, interactions between seasonal cycles and business cycles raise serious questions about standard methods of seasonal adjustment. Krane and William L. Wascher (1995), building on work of James H. Stock and Mark W. Watson (1989, 1991), develop a multivariate framework that addresses some of the statistical difficulties involved in dealing with such interactions. But there still remains the basic issue of whether the interaction term should be treated as “seasonal” or “cyclical,” and, at a more fundamental level, whether seasonal adjustment makes sense at all when seasonals and cycles do not neatly decompose.

Another area for future exploration involves the implications of our capacity-constraint explanation for interactions between seasonal and cyclical variation. If the key to the interactions is the degree to which capacity can be adjusted in different industries, then the amplitude of seasonal and cyclical interactions should be correlated with capacity adjustment costs. A test of this correlation would be of considerable interest.

REFERENCES


