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Abstract

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 face 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)

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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 costs 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 "interactions" 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 industry. 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 information, 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 inventories 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 detect does not allow us to identify the shapes of the marginal-production-cost curves.

This work builds on that of Robert B. Barsky and Jeffrey A. Miron (1989), J. Joseph Beaulieu and Miron (1991 and 1992), Spencer D. Krane (1993), and Miron and Stephen P. Zeldes (1988 and 1989), all of whom use information on seasonal cycles to provide insights into economic behavior; Olivier J. Blanchard (1983), Kenneth D. West (1986), Krane and Steven N. Braun (1991), Ray C. Fair (1989), and Anil K Kashyap and David W. Wilcox (1993) who analyze the cost structure of production; Eric Ghysels (1991), who documents the statistical asymmetries in seasonal fluctuations; 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, Jeffrey K. Mackie-Mason and Miron (1992), who show that the amplitude of seasonal cycles is positively correlated with the amplitude of business cycles, both across industries and across countries. We view their finding as complementary to ours. An important distinguishing feature of our effort is that by jointly analyzing production and inventory data we are able to establish the conditions under which any interactions between cyclical and seasonal variation can be used to learn about the shape of industry cost curves.

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

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 production 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 second generic shape is either upward-sloping and concave, or downward-sloping and convex. 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 develop a technique for distinguishing among three marginal-production-cost curves: (1) 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 representative firm chooses its productive capacity prior to the start of the first period. Once this choice has been

[2]In cases where the holding cost function is sufficiently convex so as to guarantee an interior optimum, the curvature of the holding cost function will force the firm to behave as if it is capacity constrained.

made, the state of the business cycle is revealed; both capacity and the state of the business cycle remain fixed for the rest of time. As a harmless normalization, we assume that production 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 period equals the expected marginal cost of producing an extra unit in the second period. Stated in slightly different terms, optimal production scheduling requires that the difference between marginal production costs in the seasons must equal the marginal cost of holding inventories across the two seasons.[3] We emphasize that *this requirement must hold irrespective 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.[4]

In many circumstances we will be able to describe the marginal-production-cost curve if we are allowed to observe two pieces of information: 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, suppose 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 function. How so? Given the assumed convexity of the holding-cost function, the positive correlation between

[3]A first-order condition of this type falls out of all standard production scheduling problems. See, inter alia, Charles F. Holt, Franco Modigliani, John Muth and Herbert Simon (1960), West (1986), Ramey (1991), and Kashyap and Wilcox (1993).

[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?

		As the economy strengthens, do firms carry less, the same amount, or more *inventories* into the high-production season?		
		less	the same amount	more
During a boom, does the seasonal amplitude of *production* increase, stay the same or decrease?	Increase	flattening out	flattening out	could be any of the three
	Stay the same	flattening out	linear	capacity constrained
	Decrease	could be any of the three	capacity constrained	capacity constrained

the state of the business cycle and the level of inventories carried into the second period implies that the difference between second- and first-period marginal production costs must increase as the economy strengthens. A greater difference between marginal production 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 reasoning 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 season 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 information: 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. Unfortunately, there is no guarantee that this guide will be as exhaustive once adapted for use with 12 seasons rather than just 2. 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.

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:

$$lnQ_t - ln\overline{Q_t} = \sum_{i=1}^{12} s_{it} f_i(\lambda_t), \tag{1}$$

where the s_{it}'s are conventional seasonal dummy variables ($s_{it} = 1$ if month t is the ith month of the year, 0 otherwise), λ_t is a stationary variable indicating the stage of the business cycle, $f_i(.)$ is differentiable, and $ln\overline{Q_t}$ 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

$$lnQ_t - ln\overline{Q_t} = \sum_{i=1}^{12} \sigma_i s_{it} + \sum_{i=1}^{12} \phi_i s_{it} \lambda_t. \tag{2}$$

The coefficients ϕ_i determine the interaction between the seasonal and cyclical influences on production.

Following Bell and Hillmer (1984), we rewrite (2) as

$$lnQ_t - ln\overline{Q_t} = \overline{\sigma} + \overline{\phi}\lambda_t + \sum_{i=1}^{11}(\sigma_i - \overline{\sigma})(s_{it} - s_{12t}) + \sum_{i=1}^{11}(\phi_i - \overline{\phi})(s_{it} - s_{12t})\lambda_t \tag{3}$$

where $\overline{\sigma}$ and $\overline{\phi}$ are the means of the σ_i's and ϕ_i's, respectively. The conventional assumption is that $\phi_i = \overline{\phi}$, 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 $ln\overline{Q_t}$ is as combination of a linear trend and a (presumably nonstationary) variable ν_t. This leads us to difference (3), so that

$$\Delta lnQ_t = \alpha + \overline{\phi}\Delta\lambda_t + \sum_{i=1}^{11} \Delta\{[(\sigma_i - \overline{\sigma}) + (\phi_i - \overline{\phi})\lambda_t](s_{it} - s_{12t})\} + \Delta\nu_t \quad , \tag{4}$$

where α is the slope of the linear trend in $ln\overline{Q_t}$.

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 Miron and Zeldes (1989), Patricia Reagan and Dennis P. Sheehan (1985), West (1983), and Douglas Holtz-Eakin and Blinder (1983). We updated the data used by these other 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 (West (1983) and Holtz-Eakin and Blinder (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 ended the sample period in December 1986 in order 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 λ_t to be the one-month lag of capacity utilization in total manufacturing.[5]

We begin by testing whether the interaction coefficients $\{\phi_i - \overline{\phi}\}$ are jointly significant. To this end, we define the variable $\phi = (\phi_1 - \overline{\phi}, ..., \phi_{11} - \overline{\phi})$, and test the hypothesis $H_0 : \phi = \mathbf{0}$ against $H_a : \phi \neq \mathbf{0}$. 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.[6]

We next investigate the nature of the changes in the seasonal pattern of produc-

[5]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.

[6]We also note that these series are very seasonal. In sixteen of the twenty 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.

tion 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 $D_i(\lambda_t) = [(\sigma_i - \overline{\sigma}) + (\phi_i - \overline{\phi})\lambda_t]^2$. We summarize the behavior of all 12 D_i's over the business cycle by constructing the following ratio $\mathcal{R} = \frac{\sum_{i=1}^{12} D_i(\lambda^h)}{\sum_{i=1}^{12} D_i(\lambda^\ell)}$ where λ_h and λ_ℓ are, respectively, the means of all recorded values of λ_t above the 85th percentile and below the 15th percentile of λ_t. If the seasonal variability of production tends to shrink as the economy strengthens, $\mathcal{R}$ will be less than 1. Columns (3) and (8) of Table 2 show our estimates of $\mathcal{R}$ and, in brackets, the p-values for the tests that $\mathcal{R}$ equals 1. (We executed these tests using the delta method.) For 15 of the 20 two-digit manufacturing industries, the point estimate of $\mathcal{R}$ is less than 1. In six of these cases, the discrepancy from 1 is statistically significant at the 7 percent level or better.[7] In no case is $\mathcal{R}$ 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 production and inventories. To that end, we introduce the analogue for inventories to the specification we examined earlier for production:

$$\Delta lnI_t = \gamma + \overline{\omega}\Delta\lambda_t + \sum_{i=1}^{11} \Delta\{[(\beta_i - \overline{\beta}) + (\omega_i - \overline{\omega})\lambda_t](s_{it} - s_{12t})\} + \Delta\epsilon_t \qquad (5)$$

The coefficients $(\omega_i - \overline{\omega})$ 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

[7] We also re-estimated equation (4) using lagged own-industry capacity utilization as the proxy for λ_t, and instrumenting for own-industry capacity using aggregate manufacturing capacity utilization. This procedure yielded very similar results to those shown in Table 2.

with respect to the seasonal in production—by stacking equations (4) and (5), and calculating the correlation between the inventory interaction coefficient $(\omega_i - \overline{\omega})$ and the production seasonal in the following month, $(\sigma_{i+1} - \overline{\sigma})$. 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 twenty 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_i'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 countercyclically. This case is further complicated by the fact that we cannot reject the null hypothesis that $\mathcal{R}$=1.

Unfortunately, we are unable to classify any of the remaining 13 industries. The ambiguity come because we cannot reject either the null of constant seasonal variability over the business cycle of production ($\mathcal{R} = 1$) or the null of no correlation between the inventory interaction and the production seasonal ($\rho = 0$). 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.[8]

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 reflect that marginal-production-cost curves are either upward-sloping and concave, or downward-sloping and convex. In either case, firms

[8]We investigated the robustness of our classifications with respect to various splits of the sample period. We re-estimated our results over the following sub-periods: 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 sub-periods. There were several instances in which industries that had defied classification over the full sample were classifiable over one or more of the sub-periods. 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.

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 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

Barsky, Robert B. and Jeffrey A. Miron, 'The Seasonal Cycle and the Business Cycle,' *Journal of Political Economy*, June 1989, 97(3), pp. 503-535.

Beaulieu, J. Joseph, Jeffrey K. MacKie-Mason, and Jeffrey A. Miron, 'Why Do Countries and Industries with Large Seasonal Cycles Also Have Large Business Cycles?' *Quarterly Journal of Economics*, May 1992, 107(2), pp. 621-656.

Beaulieu, J. Joseph and Jeffrey A. Miron, 'The Seasonal Cycle in U.S. Manufacturing,' *Economics Letters*, October 1991, 37(2), pp. 115-118.

______ and ______ , 'A Cross Country Comparison of Seasonal Cycles and Business Cycles,' *Economic Journal*, July 1992, 102(413), pp. 772-788.

Bell, R. William, and Steven C. Hillmer, 'Issues Involved With the Seasonal Adjustment of Economic Time Series,' *Journal of Business and Economic Statistics*, October 1984, 2(4), pp. 291-320.

Blanchard, Olivier J., 'The Production and Inventory Behavior of the American Automobile Industry,' *Journal of Political Economy*, June 1983, 91(3), pp. 365-400.

Blinder, Alan S., 'Can the Production Smoothing Model of Inventory Behavior Be Saved?' *Quarterly Journal of Economics*, August 1986, 101(3), pp. 431-53.

______ and Louis J. Maccini, 'Taking Stock: A Critical Assessment of Recent Research on Inventories,' *Journal of Economic Perspectives*, Winter 1991, 5(1), pp. 73-96.

Fair, Ray C., 'The Production Smoothing Model is Alive and Well,' *Journal of Monetary Economics*, November 1989, 24(3), pp. 353-70.

Ghysels, Eric 'On Seasonal Asymmetries and Their Implications for Stochastic and Deterministic Models of Seasonality,' mimeo., University of Montreal (1991).

Hall, Robert E. *Booms and Recessions in a Noisy Economy* New Haven, Conn.: Yale University Press, 1991.

Holt, Charles F., Franco Modigliani, John Muth, and Herbert A. Simon, *Planning, Production, Inventories and the Work Force*, Englewood Cliffs, NJ: Prentice-Hall, 1960.

Holtz-Eakin, Douglas and Alan Blinder, 'Constant Dollar Manufacturers' Inventories: A Note,' mimeo, Syracuse University, 1983.

Kashyap, Anil K and David W. Wilcox, 'Production and Inventory Control at the General Motors Corporation During the 1920s and 1930s,' *American Economic Review*, June 1993, 83(3), pp. 383-401.

Krane, Spencer D., 'Induced Seasonality and Production-Smoothing Models of Inventory Behavior,' *Journal of Econometrics*, January-February 1993, 55 (1-2), pp. 135-68.

______ and Steven N. Braun, 'Production Smoothing Evidence from Physical Product Data,' *Journal of Political Economy*, June 1991, 99(3), pp. 558-81.

______ and William L. Wascher, 'The Cyclical Sensitivity of Seasonality in U.S. Employment,' Finance and Economics Discussion Series, No. 95-43, Federal Reserve Board, September 1995.

Miron, Jeffrey A. and Stephen P. Zeldes, 'Seasonality, Cost Shocks, and the Production Smoothing Model of Inventories,' *Econometrica*, July 1988, 56(4), pp. 877-908.

______ and ______, 'Production, Inventories, and Sales: An Identity that Doesn't Add Up,' *Journal of Monetary Economics*, July 1989, 24(1), pp. 31-51.

Newey, Whitney K. and Kenneth D. West, 'A Simple, Positive Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix,' *Econometrica*, May 1987, 55(3), pp. 703-8.

Ramey, Valerie A. 'Non-Convex Costs and the Behavior of Inventories,' *Journal of Political Economy*, April 1991, 99 (2), pp. 306-34.

Reagan, Patricia and Dennis P. Sheehan, 'The Stylized Facts About the Behavior of Manufacturers' Inventories and Backorders Over the Business Cycle: 1959-1980,' *Journal of Monetary Economics*, March 1985, 15(2), pp. 217-46.

Stock, James H. and Mark W. Watson, 'New Indexes of Coincident Indicators' *NBER Macroeconomics Annual* 1989, 351-94.

______ and ______, 'A Probability Model of the Coincident Economic Indicator,' in Kajal Lahiri and Geoffrey H. Moore, eds. *Leading Economic Indicators: New Approaches and Forecasting Records*, Cambridge: Cambridge University Press, 1991.

West, Kenneth D., 'A Note on the Econometric Use of Constant Dollar Inventory Series,' *Economics Letters* 13(4) (December 1983) 337-341.

______ 'A Variance Bounds Test of the Linear Quadratic Inventory Model,' *Journal of Political Economy*, April 1986, 94(2), pp. 374-401.