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Measurement Issues in Production Smoothing: Evidence from Physical Unit Data

by Steven Braun and Spencer Krane

- Many studies (e.g. Blinder (1981), Blinder (1986), and West (1986)) have found that the variance of production exceeds the variance of shipments, casting doubt on the empirical validity of production smoothing inventory models.

- Most of these studies use data derived from the Census Bureau's M-3 reports, Monthly Survey of Manufacturers' Shipments, Orders, and Inventories. There are many well known problems with these data.

  We attempt to bypass these problems by considering physical unit measures of production, inventories, and shipments.

- Formal theoretical models make a distinction between the costs of holding inventories and (likely different) costs incurred if demand exceeds the amount of goods available for sale and a stockout occurs.

  We discuss the effects of this distinction on West-type tests and consider alternative tests in industries that carry unfilled orders.

Variabililty of production and sales from M-3 based data:

Let H_t, S_t, and Q_t represent measured end-of-period inventories, sales, and production, respectively. The M-3 surveys and BEA adjustments yield information on H_t and S_t. Production, and the variance of production, Var[Q], are constructed from

(1) $Q_t = H_t - H_{t-1} + S_t$

$\text{Var}[Q] = \text{Var}[\Delta H] + \text{Var}[S] + 2\,\text{Cov}[\Delta H, S]$.

Let H_t^a, S_t^a, and Q_t^a be actual inventories, sales, and production, and e_t^H and e_t^S be the measurement errors in inventories and shipments. Assuming $E[H_t e_t^H] = E[S_t e_t^S] = E[e_t^H e_t^S] = 0$,

$S_t = S_t^a + e_t^S$ $\qquad \text{Var}[S] = \text{Var}[S^a] + \text{Var}[e^S]$

$Q_t = Q_t^a + e_t^H - e_{t-1}^H + e_t^H$ $\qquad \text{Var}[Q] = \text{Var}[Q^a] + 2\,\text{Var}[\Delta e^H] + \text{Var}[e^S]$.

Thus, under these assumptions, variance measures based on (1) overstate the relative variability of Q to the extent that $\text{Var}[\Delta e^H]$ is big.

What is in e_t^H ?

- Adjustment for different cost accounting methods
- Allocation of inventories among stage of processing for nonreporting firms
- Translation from book value acquisition costs to market value
- Seasonal adjustment

Linear-quadratic problem in production, inventories and sales West (1986):

$$(2)\qquad \min_{Q_t} E_0 \sum_{t=0}^{\infty} d^t \{a_0(\Delta Q_t)^2 + a_1(Q_t)^2 + a_2(H_t - a_3 S_{t+1})^2\}$$

$$\text{s.t. } Q_t = S_t + \Delta H_t$$

Solving this cost function implies an optimal (expected) path of production, sales, and inventories $\{Q_t^*, S_t^*, H_t^*\}$, and a minimum cost path,

$$(3)\qquad C^* = E_0 \sum_{t=0}^{\infty} d^t \{a_0(\Delta Q_t^*)^2 + a_1(Q_t^*)^2 + a_2(H_t^* - a_3 S_{t+1}^*)^2\}$$

An alternative sub-optimal plan where production moves in lock-step with sales, so $Q_t = S_t^*$ and $H = 0$, yields expected costs,

$$(4)\qquad C^a = E_0 \sum_{t=0}^{\infty} d^t \{a_0(\Delta S_t^*)^2 + a_1(S_t^*)^2 + a_2(-a_3 S_{t+1}^*)^2\}$$

Because $C^a > C^*$, (4) - (3) implies the variance bound,

$$(5)\qquad 0 < a_0(\text{var}(\Delta S) - \text{var}(\Delta Q)) + a_1(\text{var}(S) - \text{var}(Q)) - a_2\text{var}(H) - 2a_2a_3\text{cov}(H, S_{+1})$$

The distinction between demand and sales:

The cost function (2) approximates a more detailed cost function that makes a distinction between holding inventories and stocking out of goods when demand, N_t, exceeds H_t. Consider an alternative cost function

$$(6) \qquad \min_{Q_t} E_0 \sum_{t=0}^{\infty} d^t (a_0(\Delta Q_t)^2 + a_1(Q_t)^2 + a_2(H_t - a_3 N_{t+1})^2 + a_4(N_t - S_t)^2).$$

$$\text{s.t. } Q_t = S_t + \Delta H_t$$

This cost function suggests two different variance bounds:

1: Similar to (3) - (6), when $Q = S^*$ and $H = 0$, (6) implies :

$$(7) \qquad 0 < a_0(\text{var}(\Delta S) - \text{var}(\Delta Q)) + a_1(\text{var}(S) - \text{var}(Q)) - a_2 \text{var}(H) - 2a_2 a_3 \text{cov}(H, N_{+1})$$

2: Consider the cost resulting a path where $Q = S = N$. This path implies the bound,

$$(8) \qquad 0 < a_0[\text{var}(\Delta N) - \text{var}(\Delta Q)] + a_1[\text{var}(N) - \text{var}(Q)] - a_2 \text{var}(H) - a_2 a_3 \text{cov}(H, N_{+1}) - a_4[\text{var}(N) - 2\text{cov}(N, S) + \text{var}(S)]$$

Thus, (6) creates two conceptual problems for the West tests:

- What if we reject one hypothesis but accept the other?
- If (6) is "true," the Euler equations derived from (2) and used to estimate the a_i's will likely produce biased parameter estimates because the missing term, $a_4(N_t - S_t)$, is probably correlated with the instruments.

Two Variance Bounds for "Production-to-Order" Industries

Childs (1967) Cost Function:

$$(9)\qquad C^{*} = \min E_0 \sum_{t=0}^{\infty} d^t \{a_0(\Delta Q_t)^2 + a_2(H_t - a_3 N_{t+1})^2 + a_4(U_t - a_5 Q_t)^2\}$$

This cost function also suggests two variance bounds tests:

1: The variance bound for the first alternative, $Q = S^{*}$ and $H = 0$, is

$$(10)\qquad 0 < a_0[\mathrm{var}(\Delta S) - \mathrm{var}(\Delta Q)] + a_4 a_5^2[\mathrm{var}(S) - \mathrm{var}(Q)] - a_2\mathrm{var}(H)$$
$$+2a_2 a_3 \mathrm{cov}(H, N_{+1}) + 2a_4 a_5[\mathrm{cov}(Q,U) - \mathrm{cov}(U,S)]$$

2: The firm dispenses with both inventories and unfilled orders, so $Q = N$ and $H = U = 0$. The variance bound is:

$$(11)\qquad 0 < a_0[\mathrm{var}(\Delta N) - \mathrm{var}(\Delta Q)] + a_4 a_5^2[\mathrm{var}(N) - \mathrm{var}(Q)] - a_2\mathrm{var}(H)$$
$$+2a_2 a_3 \mathrm{cov}(H, N_{+1}) + a_4[\mathrm{var}(U) - 2a_5\mathrm{cov}(Q,U)]$$

Table 1

Group 1: Industries with data on production, inventories, and shipments.

Industry name	Units	Primary data source
Denatured alcohol	millions of wine gallons	Bureau of Mines
Beer	millions of barrels [1]	Treasury Department
Distilled spirits	millions of tax gallons [1]	Treasury Department
Effervescent wines	millions of wine gallons	Treasury Department
Still wines	millions of wine gallons	Treasury Department
Lumber (total)	millions of board feet	National Forest Product Assoc.
Lumber (hardwood)	millions of board feet	National Forest Prodcut Assoc.
Lumber (softwood)	millions of board feet	National Forest Product Assoc.
Lumber (douglas fir) U	millions of board feet	National Forest Product Assoc.
Lumber (south. pine) U	millions of board feet	National Forest Product Assoc.
Lumber (west. pine) U	millions of board feet	Natioanl Forest Product Assoc.
Iron and steel scrap	thousands of short tons	Census and Interior
Pig iron	thousands of short tons	Amer. Iron & Steel Inst.& Census and Interior
Refinery copper	thousands of metric tons	Bureau of Mines
Slab zinc	thousands of metric tons	Bureau of Mines and Amer. Bureau of Metal Statistics
Bituminous coal	thousands of short tons	Department of Energy
Gasoline	millions of barrels	Department of Energy
Kerosene	millions of barrels	Department of Energy
Distillate fuel oil	millions of barrels	Department of Energy
Residual fuel oil	millions of barrels	Department of Energy
Jet fuel	millions of barrels	Department of Energy
Lubricants	millions of barrels	Department of Energy
Asphalt	millions of bareels	Department of Energy
Liquefied gases	millions of barrels	Department of Energy
Newsprint (Canada)	thousands of metric tons	Newsprint Assoc. of Canada
Newsprint (US)	thousands of metric tons	American Paper Institute
Synthetic rubber	thousands of metric tons	Census Bureau, Rubber Manufacturers Assoc.
Pneumatic casing	thousands	Census Bureau, Rubber Manufacturers Assoc.
Glass containers	thousand gross	Census Bureau

U: Series with data on new and unfilled orders.

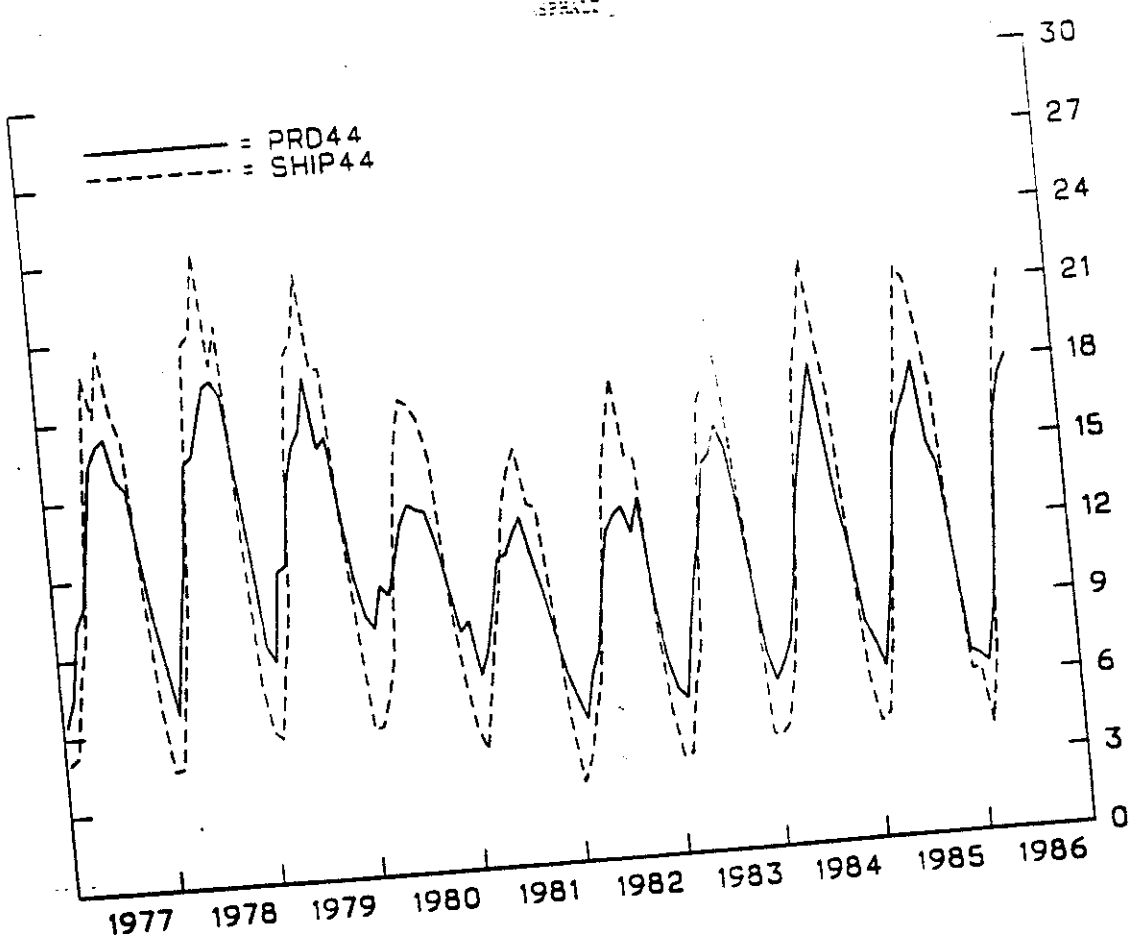
1. Shipments are recorded in millions of wine gallons.

Table 1 (cont.)

Group 2: Data on production and inventories only.

Industry name	Units	Primary data source
Sulfur	thousands of metric tons	Bureau of Mines
Superphosphates	thousands of short tons	Census Bureau
Ethyl alcohol	millions of tax gallons	Treasury Department
Whisky	millions of tax gallons	Treasury Department
Butter	millions of pounds	Agriculture Department
Cheese (total)	millions of pounnds	Agriculture Department
Cheese (American)	millions of pounds	Agriculture Department
Milk (cond. & evap.)	millions of pounds	Agriculture Department
Milk (whole dry)	millions of pounds	Agriculture Department
Milk (nonfat dry)	millions of pounds	Agriculture Department
Petroleum coke	thousands of short tons	Department of Energy
Crude petroleum ^{U}	millions of barrels	Department of Energy
Fabric (cotton) ^{U}	millions of linear yards	Census Bureau
Fabric (manmade&silk) ^{U}	millions of linear yards	Census Bureau
Fibers (acetate yarn)	millions of pounds	Textile Economics Bureau, Inc.
Fibers (rayon)	millions of pounds	Textile Economics Bureau, Inc.
Fibers (noncel. yarn)	millions of pounds	Textile Economics Bureau, Inc.
Fibers (noncel.staple)	millions of pounds	Textile Economics Bureau, Inc.
Fibers (text. glass)	millions of pounds	Textile Economics Bureau, Inc.

U: Series with data on unfilled orders.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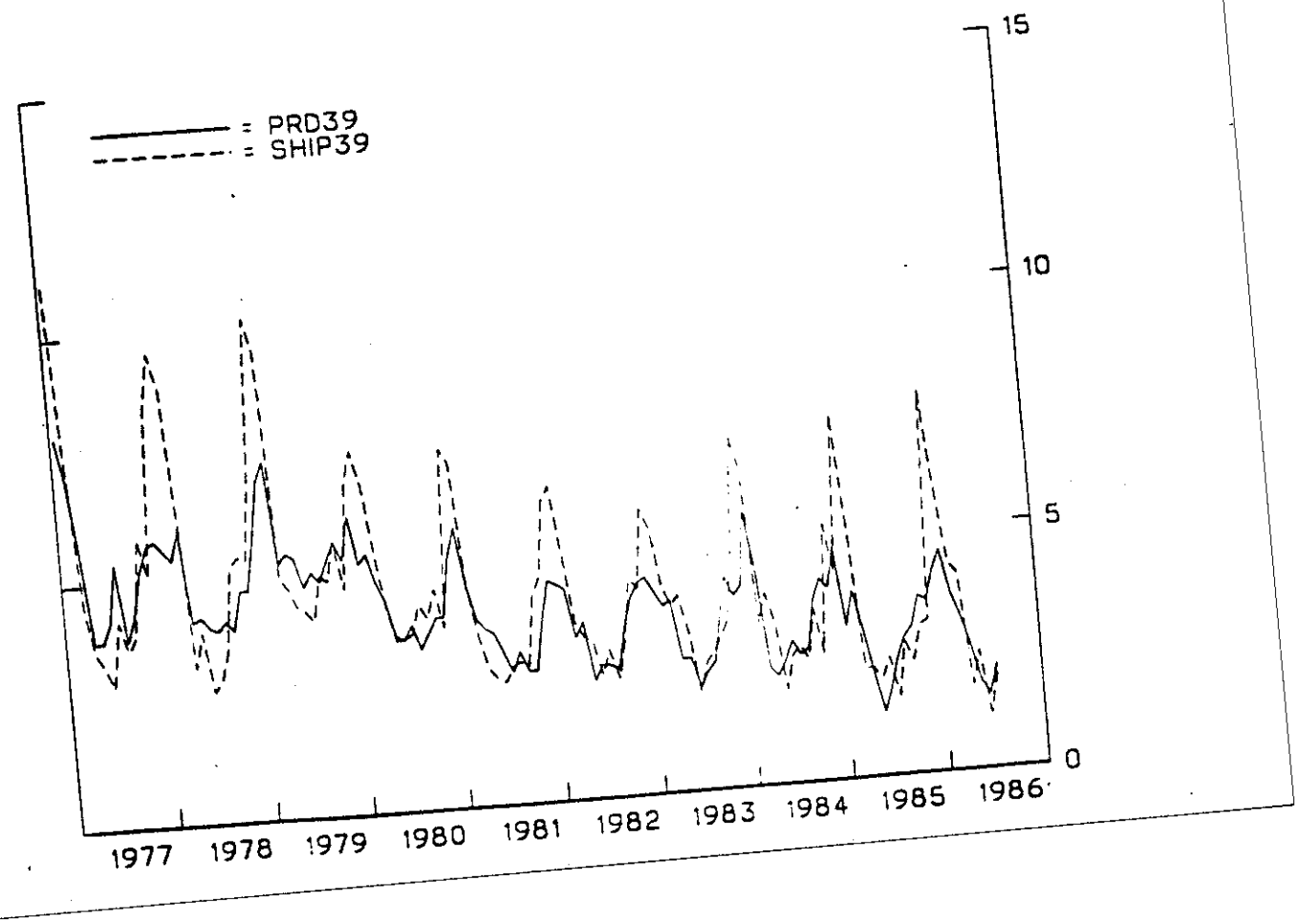
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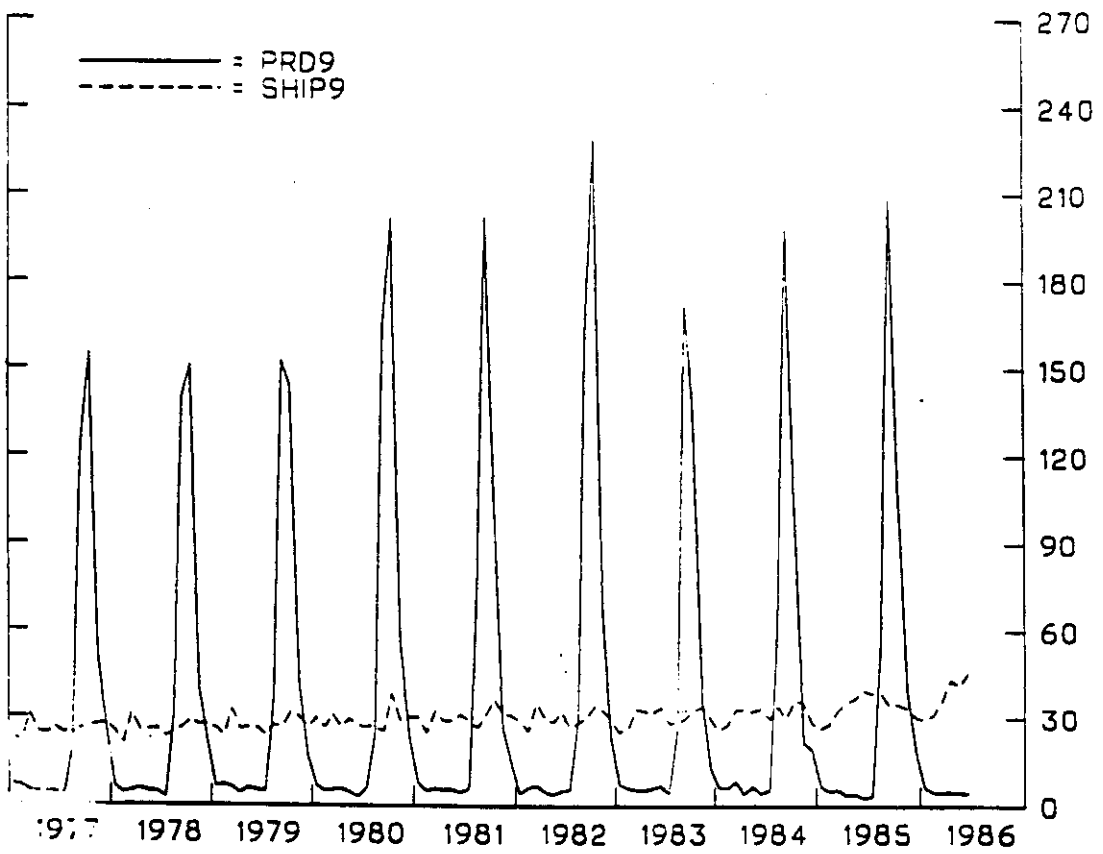

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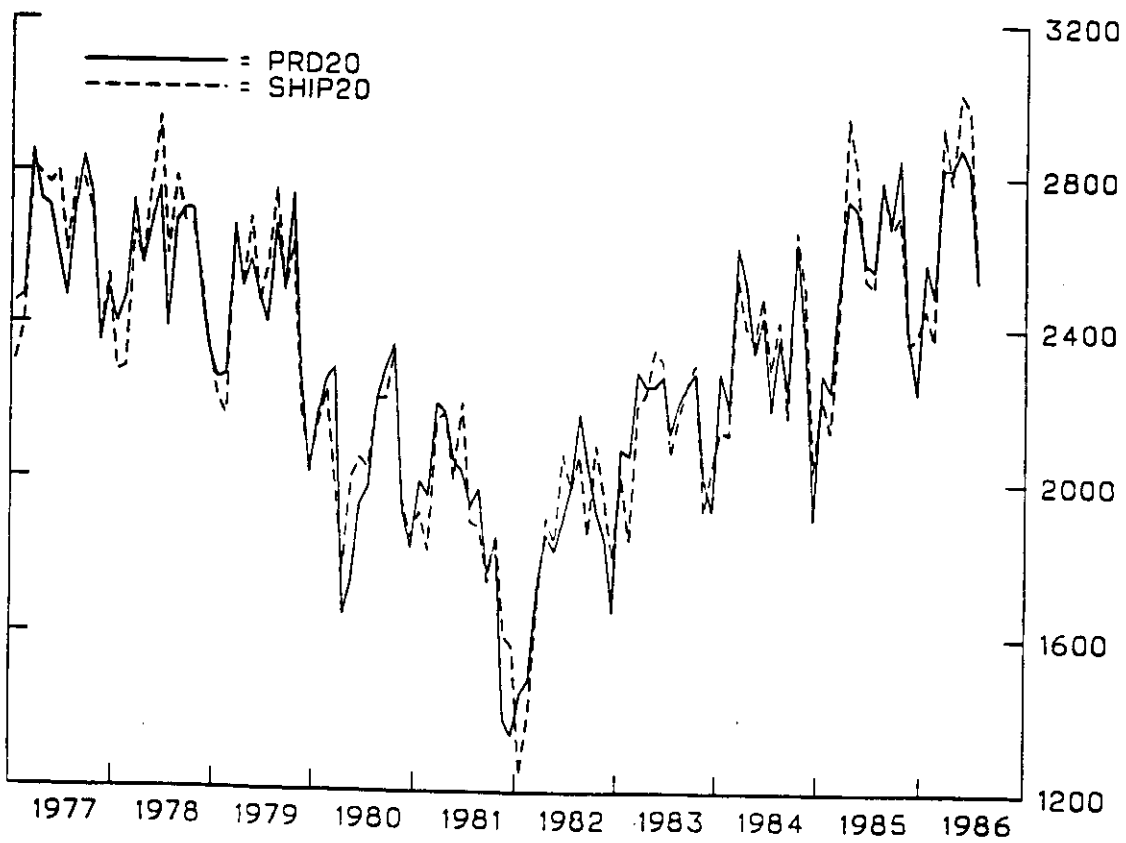

Table 2a

Summary statistics for group 1 industries.

Industry	Avg[H/S]	Var[S]/Var[Q] Total	Seas	Nonseas	Cov[ΔH,S]
Denatured alcohol	.377	.861*	1.620	.808	-.229
Beer	1.012	.873	.883*	.790	.071
Distilled spirits	17.260	4.138	5.402*	1.994	-.883
Effervescent wines	7.702	2.692*	5.724*	.840*	-.794
Still wines	17.307	.004	.002	.029	.125
Lumber (total)	2.159	1.014	1.072*	1.002	-.163
Lumber (hardwood)	3.169	.725	1.151*	.681	.233
Lumber (softwood)	1.943	1.047	1.095	1.038	-.227
Lumber (douglas fir)	1.568	.972	.968*	.972	-.190
Lumber (southern pine)	2.280	1.075	1.181*	1.066	-.266
Lumber (western pine)	1.849	.979	1.148*	.944	-.110
Pig iron	.128	.952	.877	.960	.141
Refinery copper	2.801	3.805	5.610	2.317	-.875
Slab zinc	.441	2.541*	10.354	2.187*	-.779
Bituminous coal	2.804	.252	1.121*	.091	-.298
Gasoline	1.031	1.120	1.249*	1.048	-.397
Kerosene	2.932	3.231	4.333	1.953	-.840
Distillate fuel oil	1.684	2.392	3.532	1.430	-.828
Residual fuel oil	1.228	8.040	1.322	21.128	-.942
Jet fuel	1.164	1.624	1.066*	1.864	-.779
Lubricants	2.682	1.348*	2.339*	1.176	-.573
Asphalt	2.528	2.510	3.114	1.008	-.902
Liquefied gases	2.487	8.706	26.592*	2.212	-.945
Newsprint (Canada)	.423	1.225	1.801*	1.067	-.478
Newsprint (US)	.156	.931	.733*	.993	-.096
Synthetic rubber	2.273	.951*	1.727*	.855	-.317
Pneumatic casings	2.398	1.467	2.540*	1.094	-.580
Glass containers	1.835	1.030	.771*	1.924	-.364

"*" indicates that 1.0 is outside of a 2-standard deviation interval of the estimated ratio.

The variances and covariances calculated from the VAR system:

$$Q_t = \sum_{i=1}^{3} a_i Q_{t-i} + \sum_{i=1}^{3} b_i S_{t-i} + t_Q * \text{time} + \text{seasonal dummies}$$

$$S_t = \sum_{i=1}^{3} c_i Q_{t-i} + \sum_{i=1}^{3} d_i S_{t-i} + t_S * \text{time} + \text{seasonal dummies}$$

- In 18 out of 28 cases, Var[S] > Var[Q].
- In 24 out of 28 cases, Cov[ΔH,S] < 0.

Table 2b

Relative variance of shipments and production for group 1 industries.

	Var[S]/Var[Q]		
	Direct	Implied	Implied
Industry	(A)	(B)	(C)
Denatured alcohol	.861*	.584*	1.440
Beer	.873*	.854*	1.308
Distilled spirits	4.138	.079*	41.923
Effervescent wines	2.692*	1.063	5.159*
Still wines	.004*	.004	.089*
Lumber (total)	1.014	.997*	1.018
Lumber (hardwood)	.725	.668*	.851*
Lumber (softwood)	.972	1.014	1.030
Lumber (douglas fir)	1.047	.979	.978
Lumber (southern pine)	1.075	.947	1.201
Lumber (western pine)	.979	.982*	.987*
Pig iron	.952	.988	1.027
Refinery copper	3.805	.462*	6.626
Slab zinc	2.541*	.835*	1.204
Bituminous coal	.252*	.348*	.340
Gasoline	1.120	.878	1.160
Kerosene	3.231	2.253	2.653
Distillate fuel oil	2.392	1.535	2.582
Residual fuel oil	8.040	.824*	3.415
Jet fuel	1.624	.494*	.946
Lubricants	1.348*	1.149*	1.402*
Asphalt	2.510*	2.279*	2.377*
Liquefied gases	8.706	3.599	9.562
Newsprint (Canada)	1.225	1.207	1.188
Newsprint (US)	.931	.931*	.928
Synthetic rubber	.951*	.385*	2.227
Pneumatic casings	1.467*	.888	1.622
Glass containers	1.030	.830	1.202

(A) Based on VAR between production and shipments.
(B) Based on VAR between shipments and inventories.
(C) Based on VAR between production and inventories.

"*" indicates that 1.0 is outside of a 2-standard deviation interval of the estimated ratio.

- In (A), Var[S] > Var[Q] in 18 out of 28 cases.
- In (B), Var[S] > Var[Q] in 8 out of 28 cases.
- In (C), Var[S] > Var[Q] in 22 out of 28 cases.

Table 3

Summary statistics for group 2 industries.

Industry	Avg[H/S]	Var[S]/Var[Q] Total	Seas	Nonseas	Cov[ΔH,S]
Sulfur	4.487	1.886	1.296	1.931	-.089
Superphosphates	.798	1.061	3.844	.891	-.263
Ethyl alcohol	1.557	3.330	5.814	2.991	-.302
Whisky	56.643	17.752	5.809*	29.945	-.779
Petroleum coke	.531	1.461	1.501	1.443	-.187
Crude petroleum	2.312	2.257	.905*	5.060	-.356
Fabric (cotton)	1.292	1.229	1.263*	1.209	-.349
Fabric (manmade & silk)	1.098	1.164	1.203	1.141	-.336
Variables with split data:					
First sample:					
Butter	3.574	.667	.118**	5.021	-.095
Cheese (total)	1.756	.746	.319*	4.396	-.162
Cheese (American)	2.476	.771	.348*	4.630	-.099
Milk (cond. & evap.)	1.355	2.099	2.304	1.765	-.237
Milk (whole dry)	.808	.590*	1.030*	.496	-.142
Milk (nonfat dry)	.980	.848	.703	2.255	-.180
Fibers (acetate yarn)Q	.327	.920*	2.788	.888	-.046
Fibers (rayon)Q	.423	.898	.844	.900	-.078
Fibers (noncellul. yarn)Q	.393	1.116	6.097	1.116	-.603
Fibers (noncellul. staple)Q	.419	1.063*	2.564	1.058*	-.142
Fibers (textile glass)Q	.507	.951	5.096	.938	.082
Second sample:					
Butter	3.183	.614	.376**	1.013	-.098
Cheese (total)	2.350	.874	.487*	1.423	-.138
Cheese (American)	3.648	.515	.206	.750	-.070
Milk (cond. & evap.)	1.670	5.303	9.367	.983	-.331
Milk (whole dry)	.646	.864*	1.434*	.710	-.295
Milk (nonfat dry)	.627	.960	.809	1.029	-.148
Fibers (acetate yarn)Q	.248	.931*	1.156	.902*	-.056
Fibers (rayon)Q	.329	1.056*	3.461	1.046**	-.195
Fibers (noncellul. yarn)Q	.356	.911*	3.155	.889*	-.033
Fibers (noncellul. staple)Q	.343	.955	3.535	.951	.002
Fibers (textile glass)Q	.504	.739	.769	.738	-.067

"Q" indicates quarterly data.
"*" indicates that 1.0 is outside of a 2-standard deviation interval of the estimated ratio.

Variances and covariances calculated from the VAR system:

$$Q_t = \sum_{i=1}^{3} a_i Q_{t-i} + \sum_{i=1}^{3} b_i H_{t-i} + t_Q * \text{time} + \text{seasonal dummies}$$

$$H_t = \sum_{i=1}^{3} c_i Q_{t-i} + \sum_{i=1}^{3} d_i H_{t-i} + t_S * \text{time} + \text{seasonal dummies}$$

- In 13 out of 30 cases, Var[S] > Var[Q].
- In 28 out of 30 cases, Cov[ΔH,S] < 0.

Table 4

Regressions of constructed on actual production for group 1 industries and production stationarity tests.

Industry	Q(12)	F-stat.	$\bar{R}^2$	t-ratios for sationarity: Unit Root	Time
Denatured alcohol	16.0	21.0	.79	-2.463*	2.263
Beer	25.1	8.78	.80	-3.477*	1.867*
Distilled spirits	21.3	5.93	.0	-3.405	-3.446
adjusted for imports	20.7	6.36	.0	--	--
Effervescent wines	20.3	7.84	.23	-2.343	1.238
adjusted for imports	13.4*	13.4	.10	--	--
Still wines	44.6*	8.09	.92	-4.684*	.279
adjusted for imports	42.4*	8.4	.92	--	--
Lumber (total)	10.0	5.55*	.99	-1.300	.774
adjusted for imports	128.4*	42.9*	.67	--	--
Lumber (hardwood)	2.2	5.46	.93	-2.250	-1.692
Lumber (softwood)	17.6	5.45	.99	-1.355	1.261
Lumber (douglas fir)	n.c.*	n.c.	1.0	-1.875	.771
Lumber (southern pine)	31.3*	.072	.92	-1.052	1.581
Lumber (western pine)	n.c.	n.c.	1.0	-1.731	.939
Pig iron	8.78	5.55	.99	-2.093*	-1.862*
Refinery copper	7.95	5.73	.13	-3.794*	-4.275*
adjusted for imports	7.76*	8.70*	.06	--	--
Slab zinc	113*	20.54*	.71	-1.857*	-1.224
Bituminous coal	42.2*	32.47*	.89	-3.928*	2.017
Gasoline	36.9*	5.47	.83	-1.856	-.559
Kerosene	20.0*	18.34*	.97	-2.852	-2.560
Distillate fuel oil	62.6*	31.58*	.88	-2.843	2.126
adjusted for imports	54.2*	24.2*	.96	--	--
Residual fuel oil	49.6*	20.55*	.0	-.824	-1.181
adjusted for imports	24.7*	26.8*	.0	--	--
Jet fuel	5.8*	21.72*	.11	-.778	.044
Lubricants	25.9*	19.92*	.85	-1.729	-1.654
Asphalt	476*	9.96	.99	-2.084	-.366
Liquefied gases	52.6*	7.46	.55	-1.348*	2.014
Newsprint (Canada)	n.c.	n.c.	1.0	-5.384*	.654
Newsprint (US)	n.c.*	n.c.*	1.0	-2.270*	2.347
Synthetic rubber	41.5*	71.07*	.50	-3.498*	-2.026
Pneumatic casing	182.7*	5.76	.65	-1.814	.182
Glass containers	21.1	5.67	.83	-2.805	-2.517

"*" indicates significance at the .05 percent level, n.c.--Not computable.

Q(12), F-stat, and $\bar{R}^2$ from the regression

$$H_t - H_{t-1} + S_t = a + b\,Q_t + u_t$$

Stationarity tests are the t-ratios on d and t_Q from the regression

$$Q_t - Q_{t-1} = c + d\,Q_{t-1} + t_Q\text{time} + \sum_{i=1}^{3} e_i (Q_{t-i} - Q_{t-i-1}) + u_t$$

Table 5

Data notes

Beer, effervescent wines, and still wines:
Shipments represent taxable withdrawals. In wine, there are significant nontaxable withdrawals (e.g. wine used as an intermediate inputs).

Distilled spirits:
Depending on the reporting State, shipments represent shipments at either the wholesale and producers level.

Lumber:
BEA comments indicate survey stock coverage is not on par with production and shipment coverage.

Refinery copper:
Shipments represent consumption by mills and smelters. Stocks include holdings by Commodity Exchange.

Slab zinc:
Shipments represent consumption by fabricators. Stocks exclude stocks held by fabricators.

Gasoline, kerosene, distillate fuel oil, residual fuel oil, jet fuel, lubricants, asphalt, and liquefied gases:
Shipments represent domestic demand, which is calculated as production plus inventory accumulation plus imports less exports.

Newsprint:
Shipment data include tonnage invoiced but not shipped.

Pneumatic casings:
Tires on consignment included in both stocks and shipments.

Table 6

Relative variance of the change in shipments and production for group 1 industries.

Industry	Var[ΔS]/Var[ΔQ] Direct (A)	Implied (B)	Implied (C)
Denatured alcohol	.713	.584*	1.440
Beer	.871	.854*	1.308
Distilled spirits	7.410	.079*	41.923
Effervescent wines	3.637*	1.063*	5.159*
Still wines	.006*	.004*	.089*
Lumber (total)	1.074	.997*	1.018
Lumber (hardwood)	.995	.682*	.851*
Lumber (softwood)	1.127	1.014	1.030*
Lumber (douglas fir)	1.106	.979	.978
Lumber (southern pine)	1.324	.947	1.201*
Lumber (western pine)	1.060	.982*	.986*
Pig iron	1.013	.988	1.027
Refinery copper	2.074	.462*	6.626
Slab zinc	4.237*	.835*	1.204
Bituminous coal	.260*	.348*	.340*
Gasoline	1.356	.878	1.160
Kerosene	4.085	2.253	2.653
Distillate fuel oil	2.587	1.535	2.582
Residual fuel oil	7.706	.824*	3.415
Jet fuel	1.290	.494*	.946
Lubricants	2.049	1.149*	1.402*
Asphalt	2.719	2.279*	2.377*
Liquefied gases	3.997	3.599	9.562
Newsprint (Canada)	1.270	1.207	1.188
Newsprint (US)	.719	.931*	.929
Synthetic rubber	1.928	.385*	2.227
Pneumatic casings	1.681	.888	1.622
Glass containers	.920	.830	1.202

(A) Based on VAR between production and shipments.
(B) Based on VAR between shipments and inventories.
(C) Based on VAR between production and inventories.

"*" indicates that 1.0 is outside of a 2-standard deviation interval of the estimated ratio.

- In (A), Var[ΔS] > Var[ΔQ] in 21 out of 28 cases.
- In (B), Var[ΔS] > Var[ΔQ] in 8 out of 28 cases.
- In (C), Var[ΔS] > Var[ΔQ] in 21 out of 28 cases.

Table 7

Summary of Euler-Equation Estimation

West (1986) Cost Function:

$$\min E_0 \sum_{t=0}^{\infty} d^t \{a_0(\Delta Q_t)^2 + a_1(Q_t)^2 + a_2(H_t - a_3 S_{t+1})^2\}$$

Euler Equation:

$$E_t\{q_{t+1} = a_0(dq_{t+2} + q) + a_2 H_t - a_2 a_3 S_{t+1} + (\text{time trend, seasonal dummies})\}$$

where $q_t \equiv Q_t - dQ_{t-1}$ and d = discount factor (.995)

	All	Industries Reporting Q_t, H_t, S_t		Industries Reporting Q_t, H_t only
		Measured Production	$Q \equiv S + \Delta H$	
Number of Correct Signs/ Number of Coefficients	86/156	66/116	63/116	20/40
Number of Industries with all Correct Signs/ Number of Industries	2/39	2/29	3/29	0/10
Instruments		S_{-1}, S_{-2}, S_{-3} Q_{-1}, Q_{-2}, Q_{-3}, H_{-4}	S_{-1}, S_{-2}, S_{-3} H_{-1}, H_{-2}, H_{-3},	S_{-1}, S_{-2}, S_{-3} Q_{-1}, Q_{-2}, Q_{-3},

Table 8

Summary of Euler Equation Estimation
For Firms Carrying Unfilled Orders

Childs (1967) Cost Function:

$$\min E_0 \sum_{t=0}^{\infty} d^t \{a_0(\Delta Q_t)^2 + a_2(H_t - a_3 N_{t+1})^2 + a_4(U_t - a_5 Q_t)^2\}$$

Euler Equation:

$$E_t\{a_0(q_{t+1} - 2q_{t+1} + q_t) + a_2(H - a_3 N) + a_4 a_5 u_{t+1} - a_4 a_5^2 q_{t+1} = 0\}$$

where $q \equiv Q_t - dQ_{t-1}$ and $u \equiv U_t - dU_{t-1}$

	All	Industries Reporting Q, H, S, U	Industries Reporting Q, H, U only
Number of Correct Signs/ Number of Coefficients	9/20	6/12	3/8
Number of Industries with all Correct Signs/ Number of Industries	0/5	0/3	0/2
Instruments		N_{-1}, N_{-2}, N_{-3} Q_{-1}, Q_{-2}, Q_{-3}, U_{-1}, U_{-2}, U_{-3}	N_{-1}, N_{-2}, N_{-3} Q_{-1}, Q_{-2}, Q_{-3}, U_{-1}, U_{-2}, U_{-3}

1. These three are softwood lumber industries: douglas fir, southern pine, and western pine.
2 These two industries are both woven fabric: 1) cotton, and 2) synthetics and silk.

Table 9

Variances of production, shipments, and demand for industries with unfilled orders.

Industry	Avg[H/S]	Var[S]/Var[Q] Total	Seas	Nonseas
Based on VAR between Q, S, and N:				
Lumber (douglas fir)	1.568	.986	.941	.991
Lumber (southern pine)	2.280	1.077	1.127	1.072
Lumber (western pine)	1.849	.932	1.076	.905
Based on VAR between Q, U, and H:				
Lumber (douglas fir)		.991	.904	1.004
Lumber (southern pine)		1.256	1.501	1.233
Lumber (western pine)		1.026	1.078	1.016
Fabric (cotton)	1.292	1.274	1.250	1.287
Fabric (manmade & silk)	1.098	1.170	1.201	1.151

Industry	Avg[H/N]	Var[N]/Var[Q] Total	Seas	Nonseas
Based on VAR between Q, S, and N:				
Lumber (douglas fir)	1.571	1.035	1.047	1.034
Lumber (southern pine)	2.289	1.203	1.263	1.197
Lumber (western pine)	1.850	.926	.898	.931
Based on VAR between Q, U, and H:				
Lumber (douglas fir)		.974	1.025	.967
Lumber (southern pine)		1.228	1.544	1.198
Lumber (western pine)		.985	.905	1.002
Fabric (cotton)	1.300	1.282	1.190	1.328
Fabric (manmade & silk)	1.020	2.484	2.178	2.667

No standard errors have been calculated.

- In 5 out of 8 cases, Var[S] > Var[Q].
- In 5 out of 8 cases, Var[N] > Var[Q].
- In 4 out of 8 cases, Var[N] > Var[S].