Derived Short-Run and Long-Run Softwood Lumber Demand and Supply

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Outline

- Short-run and long-run implied by dynamic models.
- Data frequency and its implication on short-run and long-run.
- Conditions for a consistent estimate of dynamic model.
- A single equation softwood lumber demand model.
- A single equation softwood lumber supply model.

Long-Run and Short-Run by Microeconomics

- With quasi-fixed factors—Short-run model
- Quasi-fixed variables achieves their equilibrium—Long-run model.
- Examples: Wear and Newman (1991) and Newman and Wear (1993)

More Examples

- Some lumber model include capacity
  - Bernard et al.1997,
  - Adams and Haynes, 1996
  - Adams et al. 1986
- $Y = f(\mathbf{P}, \mathbf{X}, K(\mathbf{P})) = f(\mathbf{P}, \mathbf{X})$
- They are short-run models by microeconomics.

Challenge

- It is unknown how many periods the short run implies. How fast a long-run equilibrium can be achieved?

Past Research on Transforming a Dynamic Equation into a Long-Run Equation

- Buongiorno, J., J. Chou, and R.N. Stone. 1979 derived a long-run relation from a dynamic model.
  - Assumption: stationary variables
  - Simple single equation model

$$Q_t = 1.22 + \underset{(0.08)^{***}}{0.39 Y_t} - \underset{(0.10)^{***}}{0.35 PM_t} + \underset{(0.18)^{***}}{0.89 PD_t} - \underset{(0.18)^{***}}{0.33 W_t} + \underset{(0.08)^{***}}{0.23 Q_{t-1}} + \sum_{i=2}^{12} g' z'_i D_i \qquad (5')$$

$$Q_t^e = 1.58 + 0.51 Y_t^e - 0.45 PM_t^e + 1.16 PD_t^e - 0.43 W_t^e + \sum_{i=2}^{12} v_i D_i \qquad (6)$$

ECM Example:
Long-Run and Short-Run Relations by ECM

$$\text{Short-run relation}$$

$$\Delta Y_t = 0.05 - 2.57\,\Delta X_t - 0.18 Z_{t-1} + \varepsilon_t$$

$$\text{Where}$$

$$Z_{t-1} = Y_{t-1} - \left(-500.96 - 14.30 X_{t-1} + 0.28(t-1)\right)$$

$$\text{and}$$

$$Y_{t-1} = -500.96 - 14.30 X_{t-1} + 0.28(t-1)$$

$$\text{is the long-run relation.}$$

ECM as a Representation of Cointegration

A dynamic model

$$\boldsymbol{\Gamma}(L)\mathbf{y}_t + \mathbf{B}(L)\mathbf{x}_t = \boldsymbol{\varepsilon}_t$$

The long-run model from it

$$\boldsymbol{\Gamma}(1)\mathbf{y}_t + \mathbf{B}(1)\mathbf{x}_t = \boldsymbol{\varepsilon}_t$$

The ECM transformed from the dynamic model

$$\boldsymbol{\Gamma}^*(L)\mathbf{y}_t + \mathbf{B}^*(L)\mathbf{x}_t + \boldsymbol{\Gamma}(1)\mathbf{y}_{t-1} + \mathbf{B}(1)\mathbf{x}_{t-1} = \boldsymbol{\varepsilon}_t$$

Estimate either ECM or dynamic model

To Ensure Cointegration

- **Γ**(L) must be invertible for an autoregressive model to represent a cointegration.
- and ε_t is assumed to be stationary.
- Test is available (e.g. Johansen's MLE), but not applicable in our case (explained later).

DW and Cointegration

- For a single equation model, a large Durbin-Watson statistics means that there is little chance that the residual is nonstationary.
  - DW approach zero if residual is nonstationary (Engle and Granger 1987).
  - Durbin-h may not improve very much.
- Or plotting the residual to check, often used by statisticians.

Example—Estimate ECM

- Successful ECM example
- Toppinen (1998) estimated a simultaneous equations demand and supply model for the Finnish sawlog market.
  - Johansen's Maximum likelihood method
  - Nonstationary data
  - Structural model
  - Simultaneous equation

Johansen Maximum Likelihood Method

- Estimates ECM directly
- Designed for testing the existence of cointegration.
- But ignores the relation between short-run and long-run. Because there may be more than one ECMs for one cointegration relation (Maddala and Kim 1998).
- Two sets of conditions for identification of the model.

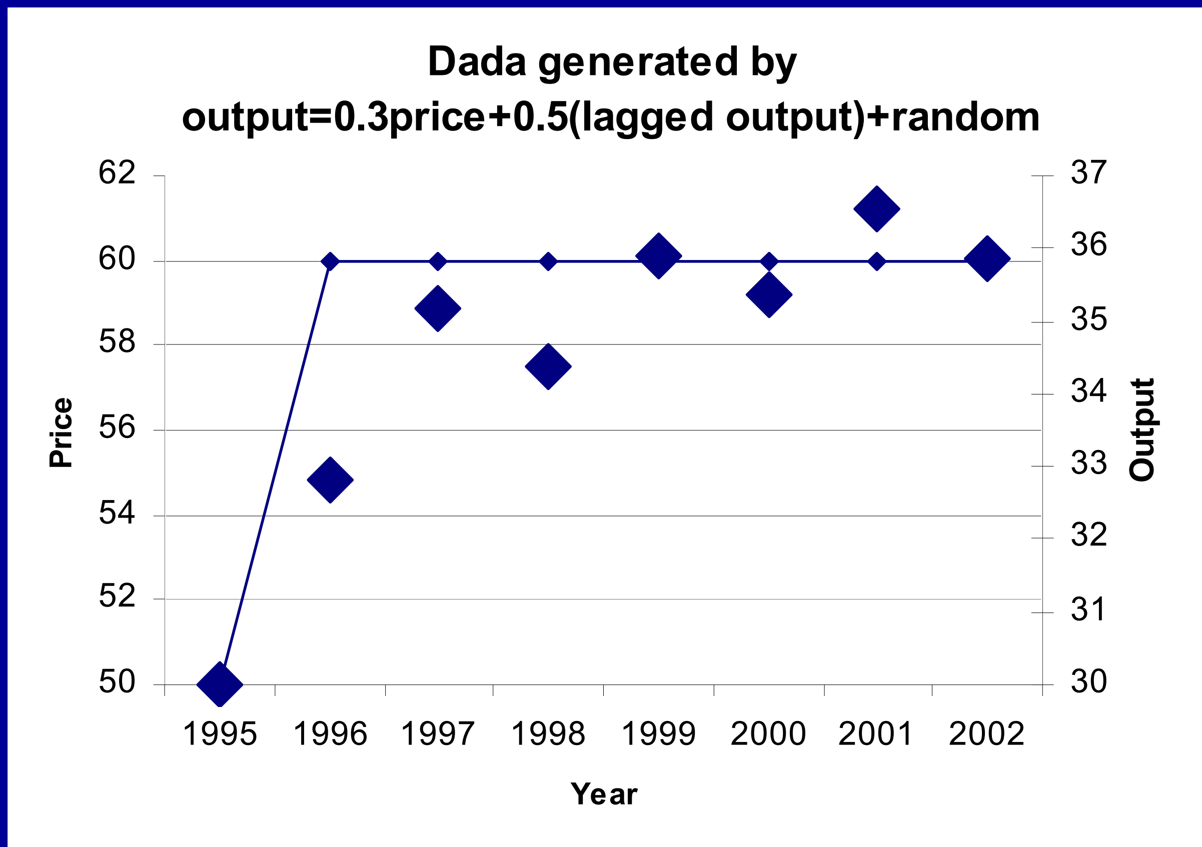
Method for Estimating Single Equation Models

- $$\boldsymbol{\Gamma}(L)\mathbf{y}_t + \mathbf{B}(L)\mathbf{x}_t = \boldsymbol{\varepsilon}_t$$
- Engle-Granger's two-step method (ignores the relation between the long-run and short-run coefficients).
- Fully modified OLS (Phillips and Hansen 1990)
- Other modified LS method (Saikkonen 1991, Stock and Watson 1993, Philips and Loretan 1991) with differenced variables to mop up the dynamic (Maddala and Kim 1998).

Fully Modified Least Squares

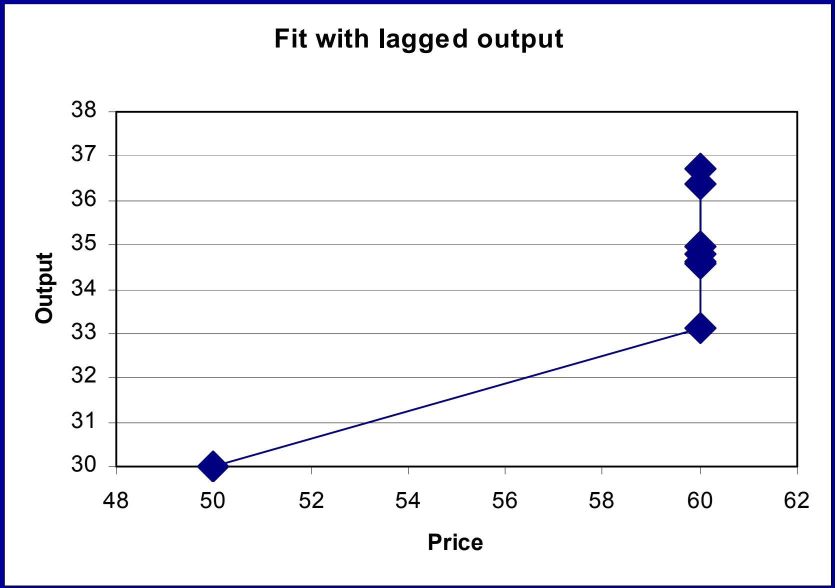
- Assumes that the error term is stationary.
- Corrects both autocorrelation and endogeneity so that dynamic models can be estimated with it.
- Even if there are endogenous variables on both side, the method can be used.
- Test statistics can be used in classical Wald tests.
- Used to estimate single equation model with nonstationary time series.

Simulated Annual Data with Lagged Response

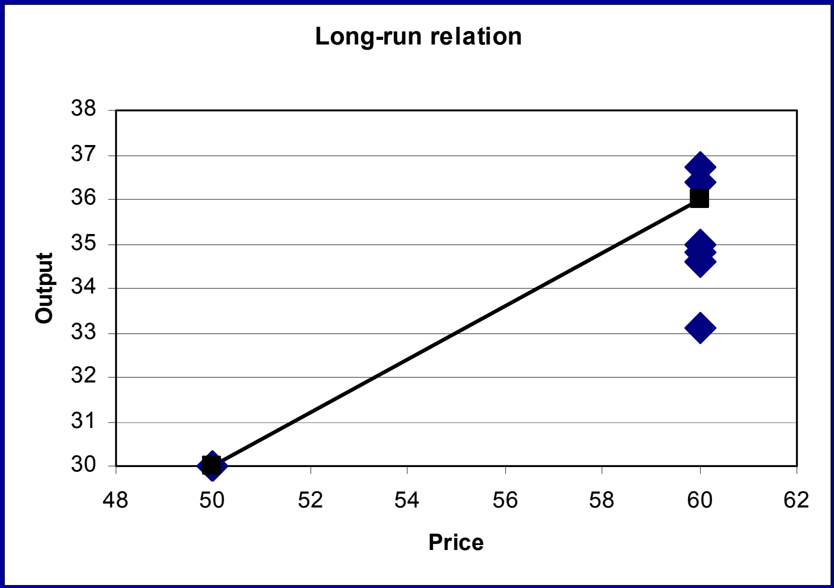


Output Against Price

- The slope of the first segment represent the short-run coefficient of price.
- The vertical line shows the lagged effects
- The equilibrium is achieved in later years



Long-Run Relation

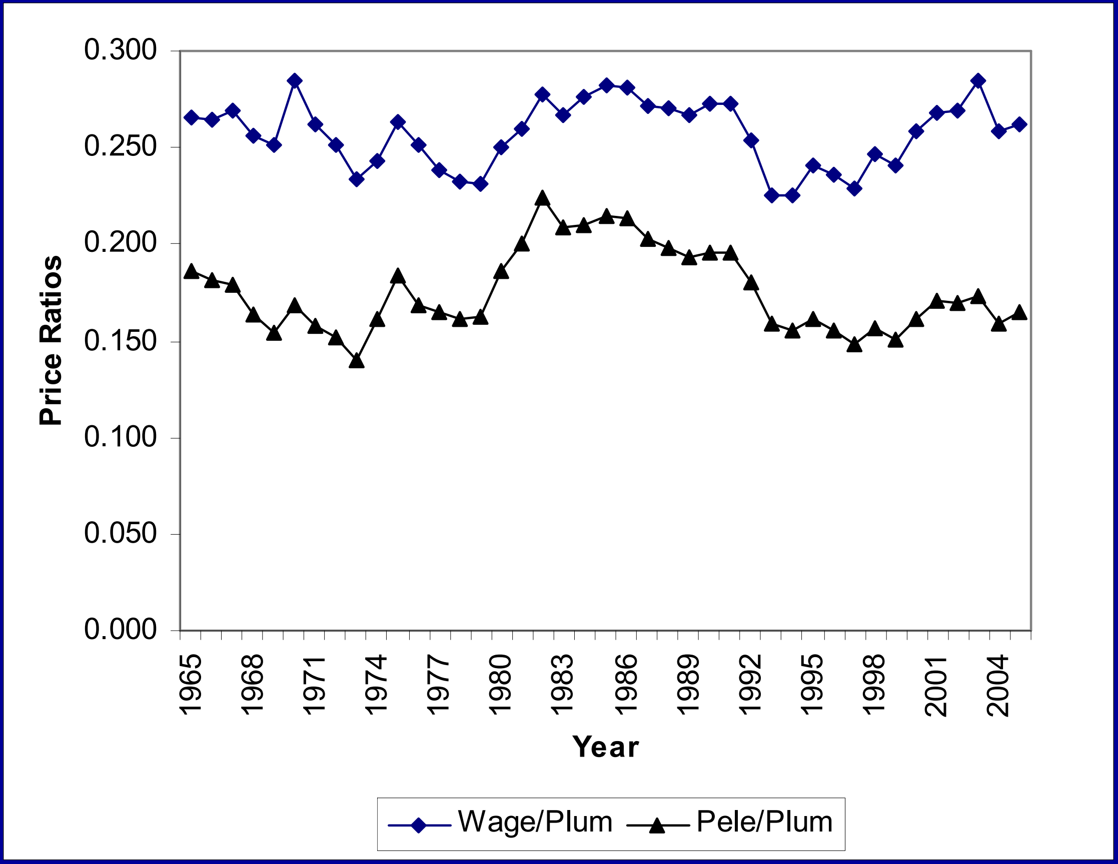


- The right end of the segment is the equilibrium point.
- The slope of the segment represents the long-run coefficient of price
- If there are no lag effects the equilibrium point is achieved in the first year.

Frequency, Short-Run and Long-Run

- With monthly data the slope of the first segment may be different so that the short-run results may be different.
- The equilibrium point should be the same so that the long-run relation estimated should be the same.

Autocorrelation and Unit-Roots



U.S Softwood Lumber Supply

- Supply equation is derived from Generalized Leontief profit function of sawmill industry (see Wear and Newman 1991, Newman and Wear 1993, Williamson et al. 2004 for such profit functions)
- Let Y_t is the softwood lumber output.
  - *m* for material (logs),
  - *w* for wage,
  - *k* for capital,
  - *e* for electricity.

$$Y_t = \alpha_{ll} + \sum_{i=m,w,k,e} \alpha_{li} \left(\frac{P_i}{P_l} \right)_t^{1/2} + \beta \alpha_l t + \gamma \alpha_{l2} t^2$$

Dynamic Supply Equation

- Add a lagged lumber production to represent the delayed response.

$$Y_t = \alpha_0 + \sum_{i=m,w,k,e} \alpha_i \left(\frac{P_i}{P_l} \right)_t^{1/2} + \alpha t + \alpha_2 t^2 + \eta Y_{t-1} + \varepsilon_t$$

Results Estimated with FMLS

- P_e has an insignificant coefficient and is excluded.
- Re-estimated results with
  - adjusted R^2 = 0.79, DW=2.17

$$Y_t = -112.86 - 2.67\left(\frac{P_{m,t}}{P_{l,t}}\right)^{1/2} + 0.24\left(\frac{P_{k,t}}{P_{l,t}}\right)^{1/2} - 4.13\left(\frac{P_{w,t}}{P_{l,t}}\right)^{1/2} + 0.06t + 0.78Y_{t-1} + \varepsilon_t$$

$$(0.02) \quad (0.00) \quad (0.66) \quad (0.78) \quad (0.01) \quad (0.00)$$

Excludes Insignificant Variables

- The adjusted R^2 = 0.81, and DW=2.05

$$Y_t = -90.17 - 2.57\left(\frac{P_{m,t}}{P_{l,t}}\right)^{1/2} + 0.05t + 0.82Y_{t-1} + \varepsilon_t$$

$$(0.09) \quad (0.00) \qquad\qquad (0.07) \qquad (0.00)$$

Derived ECM and Short-Run Elasticity

- Short-run price elasticity 0.04
- Each year 18% of the equilibrium error is adjusted.

$$\Delta Y_t = 0.05 - 2.57\Delta\left(\frac{P_{m,t}}{P_{l,t}}\right)^{1/2} - 0.18\left\{Y_{t-1} - \left(-500.96 - 14.30\left(\frac{P_m}{P_l}\right)_{t-1}^{1/2} + 0.28t\right)\right\} + \varepsilon_t$$

Long-run Relation and Price Elasticity of Supply

- The long-run price elasticity of supply is 0.23

$$Y_t = -500.96 - 14.30\left(\frac{P_m}{P_l}\right)_t^{1/2} + 0.28t$$

Elasticities of Softwood Lumber Supply Range from 0.239 to 23.62 in Past Studies

- Supply equation
  1. From profit function
     - Bernard et al.1997, Northeast SPF **0.27 (K)**
  2. Linear form
     - Adams and Haynes, 1996; **0.335 to 0.866 (K)** for different regions
     - Lewandrowski et al. 1994, **12.27-23.62(shipment), 0.35 to 0.44(production))**
     - Myneni et al. 1994; **0.27**
     - Adams et al. 1986 (Operating margin), **0.239 to 0.510(K)**
  3. Mill utility
     - Cardellichio, 1990. **0.68 to 0.7**

Softwood Lumber Demand Model

- Derived from Generalized Leontief cost function of housing industry
- Lagged dependent variable is included and
- lagged housing construction area H_{t-1} is included because housing constructions often cross two calendar years.
  - *D* is the softwood lumber demand. *me* is for metal products such as metal door, sash and trim, *c* is for concrete, *wc* is for wage rate of construction workers.

$$\left(\frac{D}{H}\right)_t = \beta_0 + \sum_{i=me,c,wc,e,k} \beta_i \left(\frac{P_i}{P_l}\right)_t^{1/2} + \beta\, t + \beta_2 t^2 + \beta_H H_t + \beta_{H1} H_{t-1} + \gamma \left(\frac{D}{H}\right)_{t-1} + v_t$$

Estimated Coefficients

	Estimated value	P-values
β_0	9.1	<0.01
β_{me}	44.83	<0.01
β_c	-30.77	<0.01
β_{wc}	-26.06	0.01
β_e	62.03	<0.01
β_k	-1.03	<0.01
β_H	-2.48	<0.01
β_{H1}	1.36	<0.01
R^2	0.9	
DW	1.8	

- Adjusted $R^2 = 0.9$
- DW = 1.8
- All P-values <= 0.01

Estimated Elasticities

Variables	Means	Short-run elasticities	Long-run elasticities
P_l	1.244	-0.32	-0.32
P_{me}	0.684	1.11	1.11
P_c	0.763	-0.81	-0.81
P_{wc}	0.12	-0.27	-0.27
P_e	0.038	0.36	0.36
P_k	6.934	-0.08	-0.08
H	2.918	0.51	≥Two years **0.78**
D	43.512		

- The long-run coefficient of H_t is -1.12, the sum of the estimated values for β_H and β_{H1}.
- Long-run housing elasticity is 0.78

Collinearity and Explanation of the Estimated Demand Equation

- Despite high correlations among price ratios, the inflated estimated variances of the coefficient are small enough to obtain significant coefficients.
- However, we do not expect the price ratios to change independently.

Collinearity and Explanation of the Estimated Demand Equation

- They change simultaneously, and thus their substitution and complementary effects together have small effect on lumber demand.

- The lumber price elasticity is -0.32 in both long run and short run.

Price Elasticities of Demand for the U.S. Market (1) of Past Studies

- Adams et al. 1986; **-0.174**
- Adams et al. 1992 **(Kalman Filter estimates)**
  residential: short-run **-0.13,** long-run **-0.55,**
  nonresidential: 3-4 time larger (long-run -**1.15**)
- Adams and Haynes, 1996, **-0.07(1985);**
- Spelter, 1985, **-0.11(1980**)

Price Elasticities of Demand for the U.S. Market (2)

- Rockel and Buongiorno, 1982, -**0.91**
- Rao et al. 2004, **-0.4275 to -1.7949** for different kinds of lumber
- Bernard et al. -**2.06** for U.S. Northeast Spruce-Pine-Fir
- Lewandrowski et al. 1994, **SP -0.667, DF -0.149, Canadian Lumber, -0.81**
- Myneni et al. 1994, **-0.10**

Conclusions-Method (1)

- Short-run and long-run demand and supply can be estimated with dynamic model.
- The estimated dynamic model can be transformed into ECM.
- Short-run implies one period by ECM.

Conclusions-Special Attention (2)

- Dynamic model must be able to represent a cointegration relation when time series have unit roots
  - Invertibility and high DW are used to ensure assumption for a FMLS
  - Other methods such as residual plot possible

Conclusion-Supply (3)

- The estimated softwood lumber supply of the U.S. market has an elasticity
  - **0.04** in the short run and
  - **0.23** in the long run,
- suggesting a very slow adjustment of the supply to the market price.

Conclusion-Demand (4)

- The estimate softwood lumber demand of the U.S. market is driven by the housing construction area.
- Each percent change in housing area result in
  - 0.51 percent of change (shift of the curve given prices) in softwood lumber demand in one year but
  - 0.78 percent of change (shift of the curve given prices) in two years.

Conclusions-Implication of Collinearity (5)

- The prices usually change simultaneously, despite their large elasticities, their total effect on lumber demand is not very large. The estimated lumber price elasticity of demand is only

- -0.32 in both the long run and the short run.

Questions/Comments