Nonstationarity, Autocorrelation, and Collinearity in Modeling Forest Products Markets

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Objectives

- Show the existence of nonstationarity
- Consequences of nonstationarity and problems in current studies
- Estimation Methods with nonstationarity data.
- Long-run and short-run
- Re-explanation of some past research.

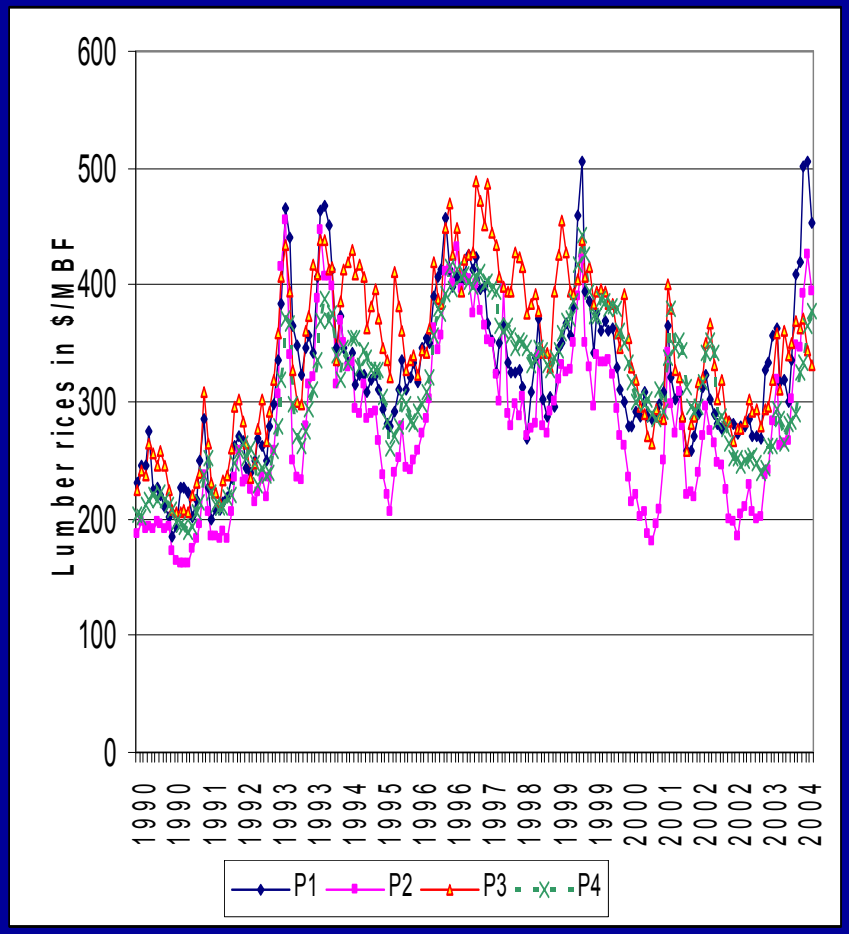
Estimation Methods

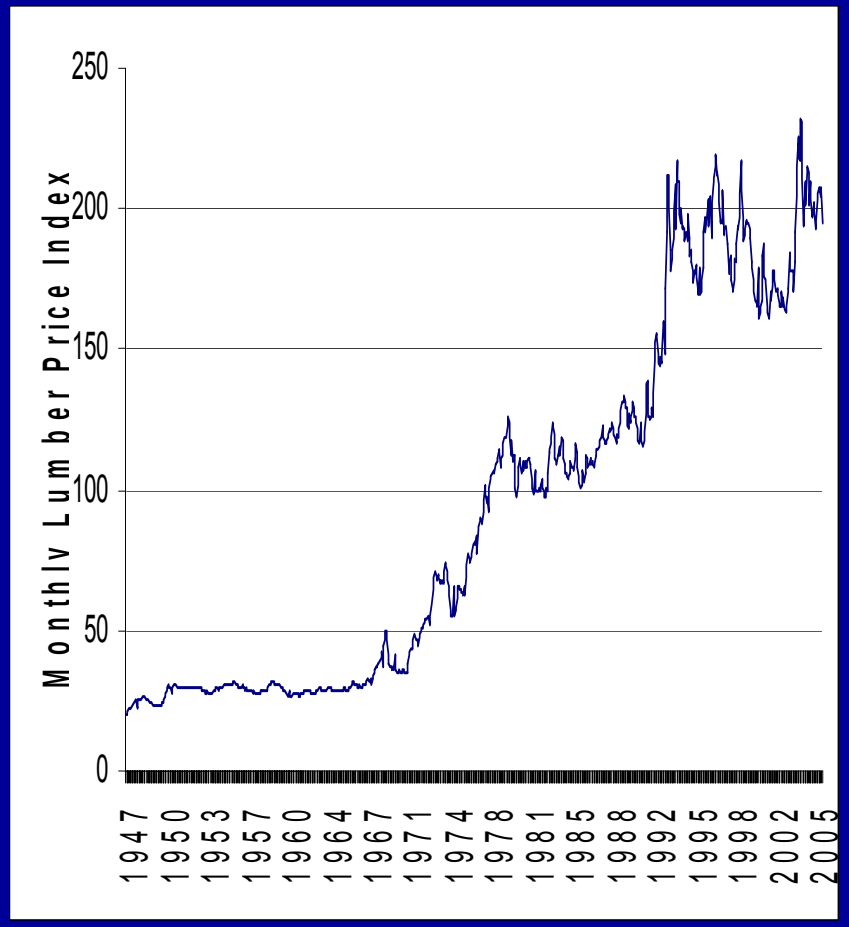
- 2SLS, 3SLS
  - Adams and Haynes, 1996;
  - Adams et al. 1986;
  - Baek and Yin, 2006;
  - Bernard et al. 1997 (NL3SLS);
  - Latta and Adams, 2000 (NL3SLS);
  - Lewandrowski et al. 1994.
- OLS
  - Rockel and Buongiorno, 1982, Adams et al. 1992, Cardellichio, 1990
- ML
  - Rao et al. 2004; Myneni, 1994
- Kalman Filter Adams et al. 1992

Nonstationarity, Unit Root

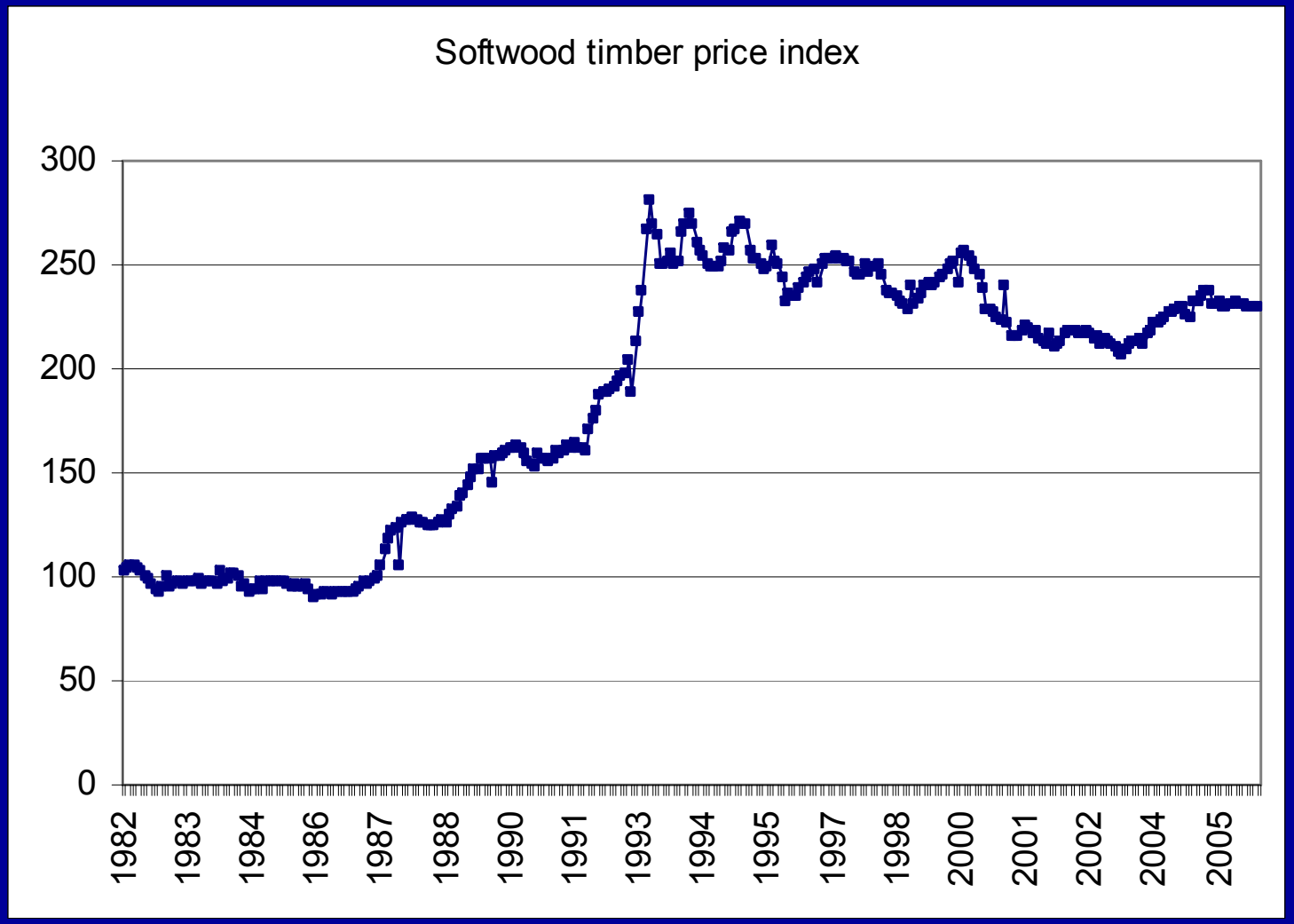
- Stationarity is a basic requirement for Central Limit Theorem (time series used in lumber models are mostly nonstationary).
- OLS with nonstationary $\{z_t\}$ is **spurious** when there is no cointegration
- Weakly stationary: $E[z_t]$ and $Var[z_t]$ are constant, and $Cov[z_t, z_{t-k}]$ is finite and independent of t
- If $A(L)\Delta z_t = \varepsilon_t$, the time series process $\{z_t\}$ has a unit root. With unit root, $\{z_t\}$ is nonstationary.

Softwood Lumber Prices are Nonstationary

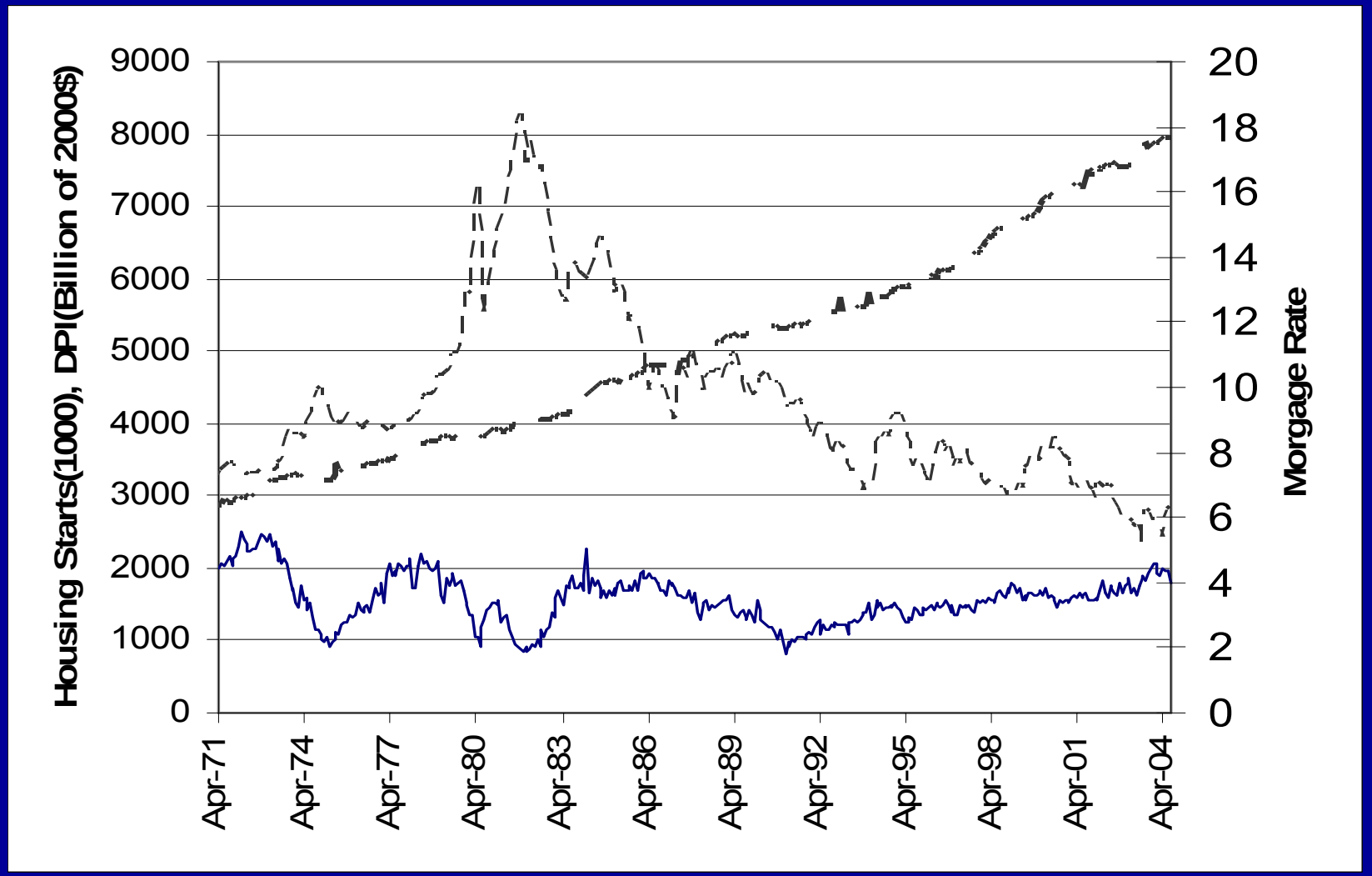




Softwood Timber Price Index



Housing Starts, Mortgage Rate and DPI



Nonstationary Time Series Studies Found

- The "law of one price" studies with cointegration tests
  - --Jung and Doroodian (1994), Nanang (2001)
  - --Buongiorno and Uusivuori (1992), Alavalapati et al. (1997) and Hänninen (1998), Yin et al. (2002), Yin et al. (2005).
- ECM models (MLE)
  - --Restricted ECM, Toppinen (1998) for Finnish sawlog
  - --Baek and Yin (2006)

Cointegration

- When a linear combination of nonstationary variables is stationary, these variables are cointegrated.
- Cointegration exists as long as market equilibrium exists.
- OLS with nonstationary $\{z_t\}$ is "**super consistent**" when there is cointegration.
- Cointegration has been used in testing "the Law of One Price" by many in forestry literature and in at least one structural models for timber, and one for lumber.

Autoregressive Representation

$$y_t = \sum_{i=0}^{p} \beta_i x_{t-i} + \sum_{j=1}^{q} \phi_j y_{t-j} + \varepsilon_t$$

- Or

$$\Gamma(L) y_t + B(L) x_t = \varepsilon_t \quad \text{where } \Gamma^{-1}(L) \text{ exists}$$

$$\text{With long} - \text{run relation}$$

$$\Gamma(1) y_t = B(1) x_t + z_t \quad \text{or} \quad y_t = \alpha x_t + z_t$$

Estimate the Autoregressive Model with 2SLS

- The coefficients of the autoregressive representation can be estimated with 2SLS or 3SLS.
- The invertability and cointegration of the model must be checked.
- Long-run relation can be obtained by transforming the estimated autoregressive representation of the cointegration.

Triangle Representation

- The source of nonstationarity of endogenous variables is the unit roots of the exogenous variables.

$$y_t = \alpha x_t + z_t$$

$$\Delta x_t = \delta + \varepsilon_t$$

Estimate the Coingretion Relations with OLS or 2SLS

- The OLS is supper consistent.
- 2SLS is consistent.
- With autocorrelation the true variance is large. However the true variance some times is not obtained by software.

ECM Representation

$$\Delta y_t = \sum_{i=0}^{p-1} \beta_i \Delta x_{t-i} + \sum_{j=1}^{p-1} \alpha_i \Delta y_{t-j} + \gamma z_{t-1} + u + \varepsilon_t$$

Estimate Structural ECM with MLE

- With restrictions an ECM can be estimated by MLE. However the cointegration test with no restriction must be applied first, and the restrictions have to be tested by a ki-square test.
- It is a pure statistical method without any knowledge prior to estimating the cointegration.
- An example is Toppinen (1998).

Misspecification

- With cointegration, Dynamic autoregressive model (ECM equivalent) is the data generating function, and the models of differences (ARIMA) are misspecified (Engle and Granger, 1987).
- By this rule, at least one of the lumber structure models published recently is misspecified.

Invertible and Stationary Coefficient Matrix

- The roots of the absolute value of the matrix $\Gamma(L)$ equal to zero must be outside the unit circle
  - In the case of one lag, the coefficient of $Y_{,t-1}$ or the ratio of the coefficient of $Y_{,t-1}$ and $Y_{,t}$ have to be less than 1 and greater than -1.

- This condition can be implemented by checking the eigenvalues of a matrix **F** (Hamilton, 1994, page 259). The absolute values of the eigenvalues must be **smaller than unit to** ensure the stationarity of the data generation system.

Past Studies

- The cointegration condition was satisfied for models estimated with OLS, 2SLS or 3SLS because of the routine reports of the DW statistics.
- Unknown for other methods.
- Some times the invertability condition is not satisfied.

Coefficient Matrix of a Recently Published Lumber Model

	-0.35			
	1.91	**1.78**	**1.70**	
	0.25			-0.36
	-1.61	**-1.45**	**-1.39**	
	0.55	-.49	-0.41	
			-0.16	
			-0.61	
				-0.30
	-0.14	0.17		0.29

The Eigenvalues of the F Matrix

- 0.962813
- 0.508607
- 0.508607
- 0.026072
- 0.026072
- -0.06027
- -0.06027
- -0.19521
- -0.19521
- -0.48036
- -0.48036
- -**1.3205** **(> 1, showing nonstationarity)**

Similar problem in another paper

- With AR(1), when $\rho>1$ the expected variance is infinite
- Values of ρ in the paper

  0.80, 0.76, 0.89, 1.02

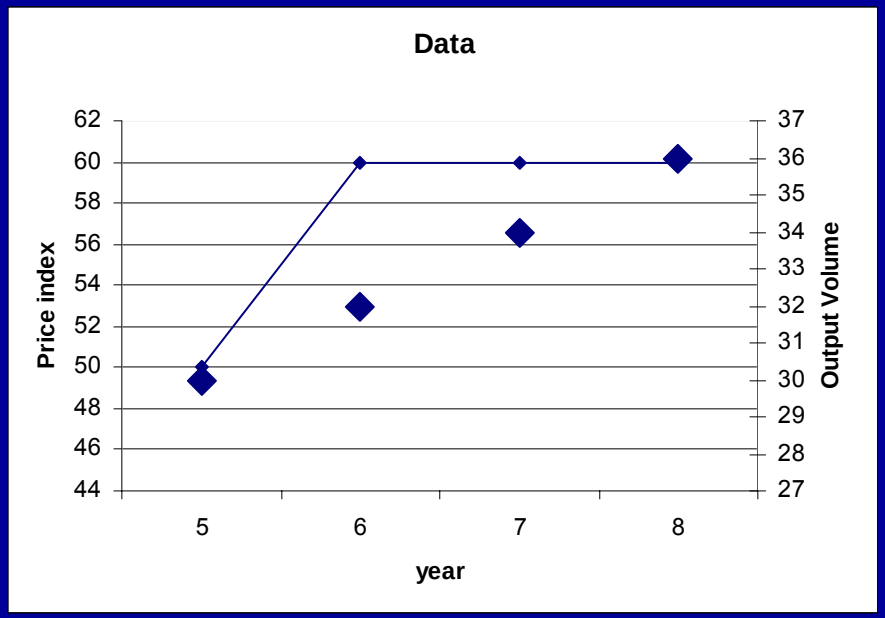
  1.25, 0.76, 0.99, 1.96

  0.44, 1.02, 1.03, 0.98

Implication of Frequency

- Estimates with monthly prices approximately equals that with annual prices in the long-run,
- But the short-run effect implied by the ECM is different

Observations over Time

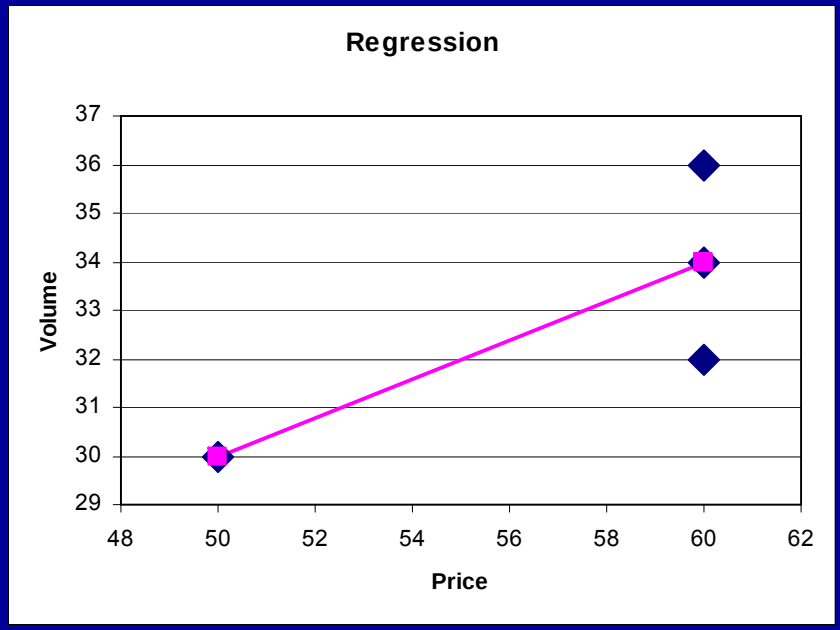


A one time increase in price (small dots over time)

The observed outputs (large diamonds over time)

With NO Lags

- Pink line: regressed curve with OLS
- Diamonds: output against price.

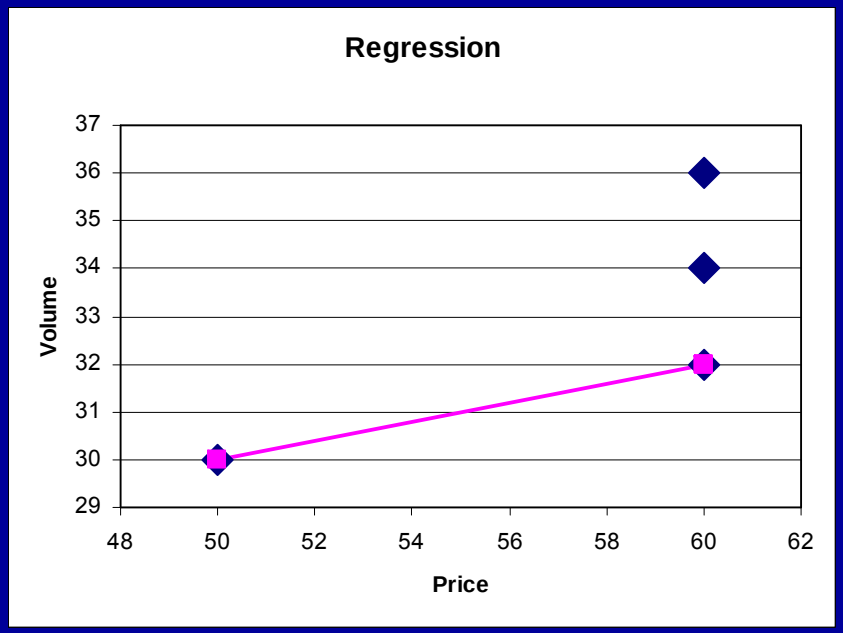


Pink line: regressed curve with OLS

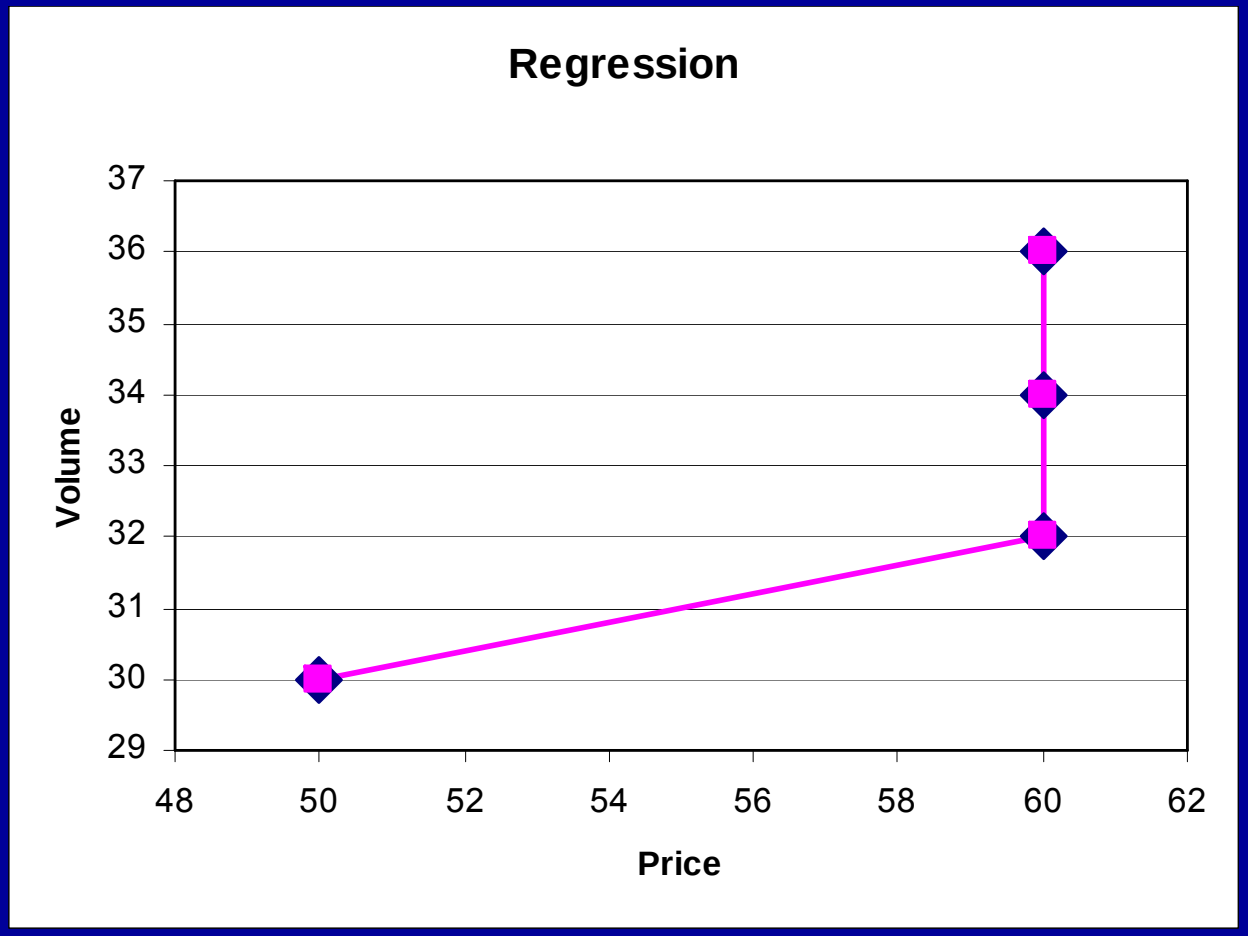
Diamonds: output against price with data on the left graph .

Short-Run Effect

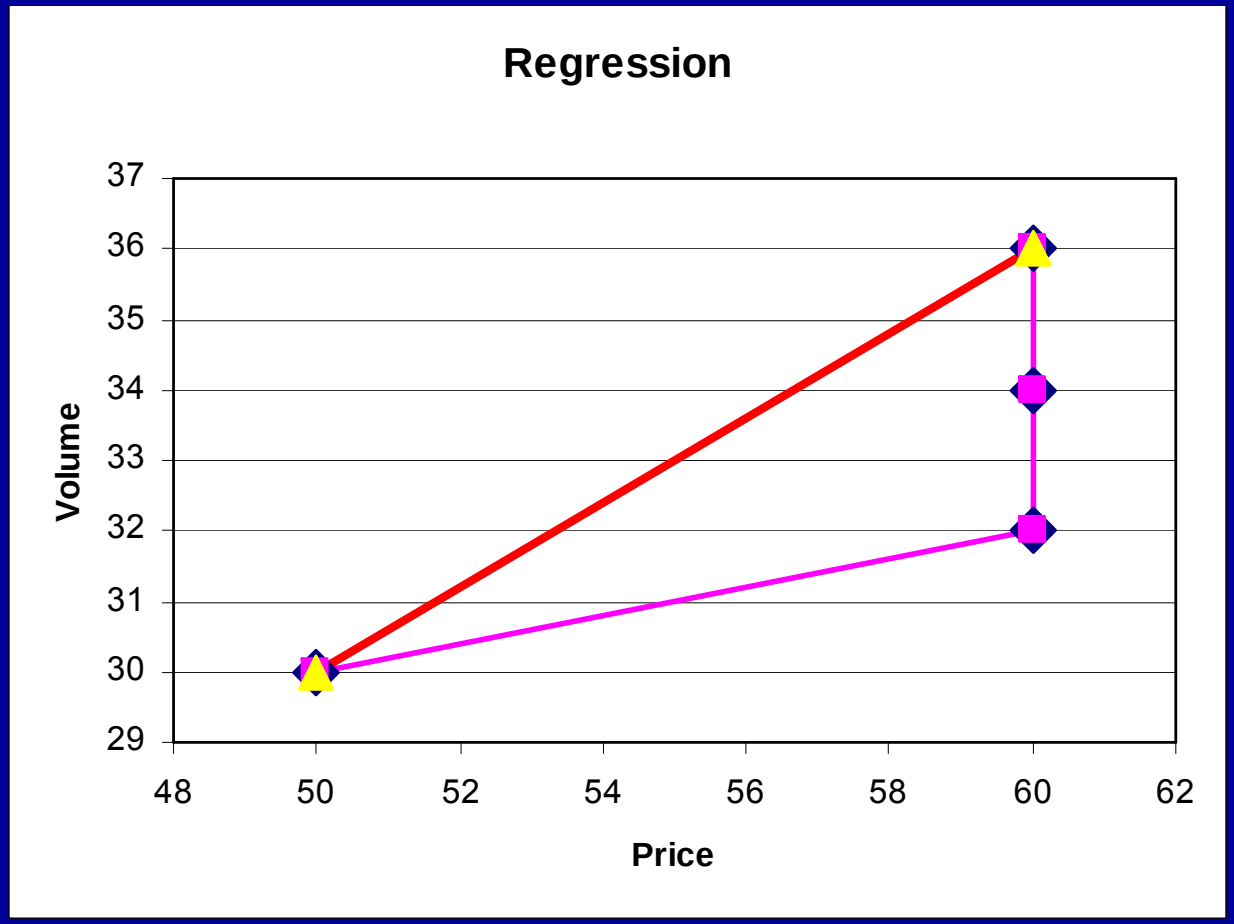
- The coefficients of differences of a ECM shows the current response.



With Lag Variables



The Long-Run Effect



Lumber Demand Elasticity

- The reported elasticities in forest literature are mostly short-run elasticity in one period of time (lags included).
- or ones below their true numbers when the autocorrelation exists in the error terms.
- According to our recent research, the long-run elasticity could be -0.71 when the often referred -0.17 is transformed according to the original estimated model.

Conclusion

- The long-run elasticity may be greater than what we thought.
- Some past models were misspecified (the impact of the misspecification is unknown)
- Some estimated system are nonstationary or unstable.
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Suggestions

- With level data, if the errors are well behaved, the unit roots of the time series can be ignored.
- The stationarity of a estimated time series model with lags of endogenous variables or autoregressive errors should always be checked.