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An Economic Analysis of Short-Run Timber Supply Around the Globe

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AN ECONOMIC ANALYSIS OF SHORT-RUN TIMBER SUPPLY

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1. INTRODUCTION

1.1 Background

CINTRAFOR is presently conducting an analysis of forest products markets in the Pacific Rim. The objective of this project is to assess the future outlook for forest products production, consumption, trade, and prices in the Pacific Rim. The focus during the current phase of this project is on solid wood product markets, log/fiber markets, and related resource developments. Although the emphasis is on Pacific Rim regions, especially those that affect the future of the Pacific Northwest, the research encompasses the entire world to maintain comprehensiveness and account for "third-party" trade interactions. The principal investigators of this project are Dr. Peter Cardellichio, Dr. Yeo Chang Youn, and Dr. Darius Adams.

This report documents our work on one important component of the Pacific Rim Assessment -- the statistical analysis and estimation of the timber supply module. For each of the 40 regions in the model, we have analyzed the current price/resource situation. Where relevant and feasible, we have constructed short-run behavioral relationships for softwood sawtimber, hardwood sawtimber, softwood pulpwood, and hardwood pulpwood. To assist with the timber supply analysis, CINTRAFOR was very fortunate to have the assistance of two visiting scientists -- Dr. Clark Binkley (Yale University) and Dr. Jeffrey Vincent (Michigan State University) -- during the summer of 1988. Dr. Binkley's major contribution involved the estimation of supply behavior in the U.S., while Dr. Vincent's work focused on supply in Southeast Asia.

A second major component of the Pacific Rim Assessment -- the development and testing of the model structure -- has already been completed. The model, which we call the CGTM (CINTRAFOR Global Trade Model), is a significantly revised version of the original IIASA GTM. (For a description of the IIASA work, see Kallio, Dykstra, and Binkley (1987)). CINTRAFOR acquired the IIASA GTM in 1986 and conducted an extensive evaluation of this model. The results of this evaluation were first reported at the Forest Sector and Trade Modeling Symposium held at the University of Washington on November 3-4, 1987 (proceedings are available) and the details are reported in Cardellichio and Adams (1988). Many of the suggestions made for improving the IIASA GTM have been incorporated into the new CGTM. Michael Pederson is responsible for the programming associated with this effort.

The two major research tasks that remain are the development of the product supply and product demand modules. We have completed a significant amount of data collection for these analyses and some of the estimation has been completed as well. We plan to have preliminary projections using the complete CGTM available by late Spring 1989.

1.2 Product and Regional Definitions

The Pacific Rim Assessment focuses on solid wood products and resources during the current phase. The specific products that we are analyzing are coniferous sawnwood, nonconiferous sawnwood, coniferous veneer and plywood, nonconiferous veneer and plywood, reconstituted panel products, and pulp. For the first four products, CGTM includes equilibrium models of supply, demand, prices, and trade. For reconstituted panels and pulp, stand-alone models are simulated and the resulting regional production levels are input to CGTM. The derived demand for pulpwood is important in this stage of the Pacific Rim Assessment because: 1) pulpwood harvests are needed to update the timber inventory models; 2) pulpwood demands are needed to determine prices endogenously for lumber and plywood residues; and, 3) pulpwood chip trade is important in Pacific Rim markets in its own right.

There are 40 regions of the world that are recognized in CGTM, and these encompass the entire globe. This geographic coverage provides the capability of adding up figures for, say coniferous log production, and comparing these with other projections of world production, such as those reported by FAO. Most of the geographic detail in the model is concentrated in the Pacific Rim regions. The hardwood-producing regions of Southeast Asia receive special attention because of their overall importance in Pacific Rim trade, and because of the substitution potential between hardwoods and softwoods in key markets like Japan and South Korea.

The CGTM regions are listed below. The regions which incorporate endogenous supply models are shown in bold type. A "+" after the region indicates that the region is the main component of a larger region. For example, China+ includes China, North Korea, and Mongolia, and India+ includes India, Bangladesh, Bhutan, Nepal, Pakistan, and Sri Lanka.

U.S.:		
	Western Washington and Oregon	(1)
	Eastern Washington and Oregon	(2)
	Inland Region	(3)
	Alaska	(4)
	California Redwood	(5)
	South	(6)
	North	(7)
Canada:		
	B.C. Coast	(8)
	Interior Canada	(9)
	Eastern Canada	(10)
Central America		(11)
South America:		
	Brazil	(12)
	Rest of North	(13)
	Chile	(14)
	Rest of South	(15)
Europe:		
	Finland	(16)
	Sweden	(17)
	Rest of Western Europe	(18)
	Rest of Eastern Europe	(19)
Asia:		
	Japan	(20)
	South Korea	(21)
	Indonesia	(22)
	East Malaysia+	(23)
	West Malaysia+	(24)
	Papua New Guinea	(25)
	Philippines	(26)
	China+	(27)
	Taiwan+	(28)
	Indochina	(29)
	India+	(30)
	Middle East	(31)
USSR:		
	Western USSR (Europe & West Siberia)	(32)
	Eastern USSR (East Siberia & Far East)	(33)

Africa:		
	North	(34)
	East	(35)
	South	(36)
	West	(37)
Oceania:		
	Australia	(38)
	New Zealand	(39)
	Rest of Oceania	(40)

1.3 Methodology

This paper provides statistical analyses of short-run timber supply for several regions of the world that influence industrial timber markets in an important way. For analytical purposes, we define log supply as the sum of two components: 1) the supply of stumpage, or standing timber; and, 2) the cost of harvesting the timber and delivering it to a mill.* Volumes are defined by wood that is harvested for eventual consumption; hence, the statistical analysis considers only supplies of, and demands for **logs**, rather than resources (logging residues are accounted for in the timber inventory equations). There is very little data that would allow one to model the efficiency of converting trees into logs, and thus changes in capital and labor usage and resulting changes in resource utilization are effectively ignored. The distinction between sawtimber and pulpwood is also defined from the consumption perspective, rather than the resource perspective: sawtimber is defined as logs that are sawn or peeled, whereas pulpwood is defined as timber that is chipped for pulp or reconstituted panels.

The short-run timber supply **curve** is defined as the relationship between the quantity of timber which is produced (or harvested) and the price. The distinction between stumpage supply and log supply is important, and is indicated by the location where the price variable is measured. The short-run timber supply **function** must account for other possible determinants of timber supply. These will vary depending on whether one is estimating the behavior of stumpage prices or harvest and delivery prices. Our decision on whether to model stumpage and harvest and

* Finland and Sweden provide special cases because prices are available for both stumpage and logs delivered to roadside.

delivery prices separately depends on their shares of delivered log prices, the availability of data, and the success of estimation.

1.3.1 Stumpage Supply

Analyzing stumpage supply with aggregate time series data significantly limits the set of variables that are useful for explaining behavior. Including a variable that measures supply potential and supply tightness is crucial, and the available inventory is the variable that is generally chosen. If timber supply is differentiated by ownership, then it may be necessary to include additional variables that reflect the special behavior of the owner group.

The inclusion of an inventory term in the supply equation raises several important issues, particularly when working with aggregate time series data. First, the correct measure of the inventory is the mature growing stock, that which has reached harvestable age. However, such measures are difficult to obtain in most regions, and the definition is imprecise because rotation ages are flexible and will adjust to changing market conditions. Second, inventory changes slowly and so it may have a minimal effect on the position of the supply curve over a small sample period. Third, and a corollary of the previous argument, it generally is not possible to determine meaningful annual fluctuations in timber inventory. This occurs for two reasons: 1) measures of aggregate standing volumes tend to be fairly inaccurate; and, 2) since the magnitude of the inventory is very large relative to the harvest and growth, the variation in the annual inventory is dwarfed by the variation in the harvest levels themselves. For all of the above reasons, the inclusion of an inventory term in the timber supply function often yields parameter estimates that are statistically insignificant. Furthermore, because of measurement and statistical problems, it is unlikely that differences in inventory elasticities between regions will be very accurate.

The theoretical arguments for including inventory in the **stumpage** supply function remain compelling however. Certainly, if the inventory increases 15% between the beginning and end of the estimation period, one expects the supply curve to shift outward, all else equal. To avoid the empirical tangle described above, we adopt the general practice of assuming that the inventory elasticity is equal to 1.0. This assumption offers several modeling advantages. First, from a theoretical standpoint it is a relatively defensible assumption. Second, it eliminates regional differences that are difficult to justify. Third, it allows us to introduce future shifts in the stumpage supply curve in response to inventory changes, even if inventory was stable in the past.

There are at least two arguments for choosing the value of 1.0 for the inventory elasticity. The most intuitive argument is based on changes in the land base. If harvesting behavior on an area of land is optimal, then adding a unit of identical land will increase the timber supply by the same percentage as the increase in inventory (which is proportional to the land area). The reasoning is analogous to that of constant returns to scale (replication) in neoclassical production theory. While this notion is useful for individuals and analyses of microbehavior, it is less applicable to the study of large regions over time. However, in cases where timberland is withdrawn from the inventory (due to protection or other land use changes), it is quite appropriate. A second argument is based on changing the inventory by changing the yield function in all age classes. (See Binkley (1985) for a discussion of this case.) Because such a change will simply shift the supply in all age classes, without altering the age-class structure of the forest, the inventory elasticity will be 1.0.*

There are clearly cases when the inventory elasticity is not equal to 1.0. Nontimber benefits can significantly alter the examples provided above. More importantly, increases in inventory due to disproportionate growth in a subset of age classes will not conform to this model. Age-class issues become particularly important in regions where there is a significant transition from immature to mature timber. Regions with large areas dedicated to plantations provide the best examples. In regions where we recognize that age-class structure poses a significant problem, we have modified the timber supply specification to reflect this. In spite of these limitations, we believe that constraining the inventory elasticity to equal 1.0 is generally warranted.

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* One notable empirical study of the inventory elasticity deserves mention here. A recent study by Dennis (1988) used Tobit analysis on a large sample of landowners in New Hampshire and determined the inventory elasticity to be equal to 1.06.

1.3.2 Harvest and Delivery Costs

With respect to harvest and delivery costs, one can postulate several factors that will affect the position of the supply curve. As with any production model, the key concerns are factor prices and factor use. The important factor prices are logging wages, fuel prices, and capital costs. Factor use will depend on parameters such as distance, terrain, and general logging conditions.

In many regions of the world, it is not possible to obtain reliable data on factor prices or the utilization rate of these factors. In regions where we have estimated such models, the parameter estimates for the variables are often insignificant, or show the wrong signs. Significant, correctly-signed variables, often show elasticities that are not reasonable. Finally, even when such models appear reasonable, one is left with the difficult task of forecasting these exogenous variables.

Due to the above considerations, we simplified the estimation of harvest and delivery costs by modeling these costs as a function of cut, or the cut-inventory ratio. For these models, it is important to distinguish between mature and immature regions. In mature timber-producing regions -- regions with well-developed infrastructures for timber production -- harvest and delivery costs generally are not very sensitive to harvest levels. For such regions, we simply forecast harvest and delivery costs exogenously. The projections are based on historical trends and anticipated changes in the real costs that govern these levels.

A critical aspect of immature regions is that expansion of the extensive margin is the primary method of increasing harvest levels. Rising prices make the penetration of new timber stands economical because producers are able to afford higher harvest and delivery costs. In such cases, one might hypothesize that timber inventory would be an important explanatory variable in the model: as the inventory declines, or as the cut rises relative to the available inventory, access costs should rise as well.

For some regions, we model only the delivered log cost. In these regions, stumpage costs tend to be an insignificant share of delivered log cost. Thus, the rationale for the delivered log cost model is basically the same as for harvest and delivery costs. We should note that inventory has the same directional effect in both the stumpage and harvest and delivery models: a reduction in inventory increases the costs of stumpage due to increased timber scarcity, and increases harvest and delivery costs due to more expensive access.

1.3.3 Timber Supply Dynamics

Timber supply dynamics are straightforward in regions that include an inventory term. Inventory in each period is calculated using a simple growth-drain relationship: inventory(t+1) = inventory(t) + growth(t) - harvest(t). Thus, the supply curve will be adjusted to reflect future inventory levels. If inventory does not appear as an argument in the supply equation, the supply curve will remain stable over the forecast horizon.

These two specifications do not preclude the possibility of shifting timber supply curves in the future in response to other factors. Exogenous shifts in these curves can be easily implemented at the analyst's discretion. For example, if information is available that suggests that changes in government policy will affect future timber availability, timber supply curves can be readily modified to reflect the necessary supply adjustments.

1.4 Estimation Procedures

In our analysis, we have assumed that timber prices and timber harvests are simultaneously determined. Due to this hypothesis, the choice between estimating timber supply in price- or quantity-dependent form obviously cannot be made on the basis of causality. At the individual timber owner level, it may be true that the price is given (exogenous) and the individual chooses the desired harvest level. However, at the aggregate market level, such a distinction is not possible. It remains true that owners will collectively sell (produce) more if prices are higher. But it is now also true that prices will rise if more timber is produced: the costs of additional harvests are greater due to opportunity costs of sacrificed future harvests and the "sale" of additional nontimber benefits. This latter interpretation is simply the argument that timber supply can be viewed as a marginal cost curve.

The choice of whether timber supply functions are estimated in price- or quantity-dependent form can have a significant effect on the regression results. Specifically, if an equation is estimated in price-dependent form, one minimizes the sum of the squared deviations between actual and fitted prices (this is generally described as minimizing the sum of squares of the <u>vertical</u> deviations). However, estimation of the supply equation in quantity-dependent form means that the sum of the squared deviations between actual and fitted quantities are minimized. This would be identical to estimating the equation in price-dependent form using a least squares rule in which one minimized the <u>horizontal</u> deviations between actual and fitted values. If the equation fits the data extremely well, then the choice between price- and quantity-dependent forms makes little difference. However, when the equation fits the data poorly, the results are likely to differ substantially.

For the purposes of the Pacific Rim Assessment analysis, we have chosen to estimate all timber supply functions in price-dependent form. We selected this strategy for three reasons. First, the use of price-dependent equations is more consistent with the general theoretical framework of the global trade model: the solution algorithm for the timber sector operates by maximization of producer surplus, and hence uses marginal cost curves. Second, the use of price-dependent functions will enhance model performance. Success in predicting a particular variable will be improved if one estimates an equation that minimizes the errors with respect to that variable. Since quantities are determined from equilibrium in the product sector, the timber supply equations may be thought of as determining price.* The greater need for accuracy in price predictions also follows from the use of marginal cost curves in the solution algorithm. Third, issues concerning errors in variables suggest that prices generally should be the dependent variable. It is commonly argued that errors in variables are more serious if the independent variables are measured with error because this will cause parameter estimates to be biased and inconsistent. There is evidence that timber

* While this argument is sound at the timber sector level, the appropriate performance test would entail simulating the full model over the historical period and examining its ability to reproduce the behavior of prices and quantities.

prices are measured with greater error than quantities. Prices are often based on unit values of traded logs in which the quality may differ significantly from the logs that are consumed domestically. Furthermore, because prices are usually constructed from total values, average prices are constructed with no regard for the fact that the product mix is heterogeneous. Failure to address this problem with appropriately-constructed price indexes will cause prices to be measured with error. Prices also are subject to other problems such as: 1) poor sampling in some regions; 2) the use of prices from some specific group of sales to proxy for prices for the industry; and, 3) government influence in pricing that may not be evident to the analyst, or may have changed during the estimation period.

All equations are estimated in log-linear form. Due to the problem of small sample size, which is often confounded by limited variation and/or structural change over the estimation period, it is not possible to choose among functional forms on the basis of goodness of fit. Because of both theoretical and data limitations, we have experimented with models with simple functional forms. We have chosen log-linear models over linear models for four reasons. First, we believe that constant-elasticity-of-supply functions are generally more consistent with economic theory. This is based on the notion that costs increase at a more rapid rate as production approaches capacity. Second, the logarithmic transformation means that the price will equal zero when the quantity equals zero. It is often the case that linear functions will result in negative price intercepts. Not only is this unreasonable from a theoretical standpoint (positive production occurs at negative prices), it may cause significant modeling problems if the optimal solution occurs in this infeasible range. Third, time series data often present the problem that the variance in the data increases over time. One method of dealing with heteroscedasticity problems is to transform the data via logarithms. Fourth, logarithmic transformations simplify the interpretation of regression results since the coefficient on the quantity term is the inverse of the supply elasticity.

All equations are estimated using ordinary least squares (OLS), although we experimented with models using nonlinear least squares in several regions. The basic reason that we chose not to use a simultaneous-equation estimator is that the results are quite sensitive to the first-stage fit, and this makes it difficult to interpret the final elasticities. If the regression of the independent variable on the instruments yields a poor fit, then the differences between the OLS and simultaneous estimator can be substantial; however, the different results may simply be due to the selection of poor instruments. On the other hand, if the first-stage regression yields a good fit, then it makes little difference which estimator one chooses. In the limit, a perfect fit means the two procedures yield identical results. Because of the small number of observations available for each regression, and because of the extensive experimentation required to determine the most suitable equation, it makes little sense to resort to rigorous econometric theory to contrast the validity of the different approaches. Practically speaking, OLS is much simpler to implement which is an important consideration given the large number of equations that needed to be estimated. All estimation was conducted with MicroTSP, Version 6.0, which was programmed by David M. Lilien. The statistical package is produced by Quantitative Micro Software in Irvine, California.

All units of measurement are expressed in metric terms -- hectares or cubic meters -- unless otherwise noted. The data base generally covers the period 1960 or 1965 to 1987. In some regions we have eliminated the earlier years if the appropriate data were not available, or if the period seemed irrelevant to the current structure and behavior of the industry. In some cases, 1987 data were not yet available. In these cases, we either estimated the 1987 data if we thought there was sufficient information to do so, or we simply omitted the 1987 observation from the sample. The equations presented in this manuscript will be revised as new data (either revised or released for the first time) become available.

1.5 Monograph Outline

This monograph is arranged by major regional groupings. The presentation format is the same for Sections 2 through 8. Each section begins with a general description of the region, its size, resource characteristics, and important industry features. The individual regions are then presented in detail. We provide an overview of key market features, and describe the data used in the analysis. Due to the large number of sources that were used to construct the final data set, the documentation of data sources is spotty. Full documentation of the data base would constitute a major report in itself -- the primary purpose of this manuscript is to describe the results of the statistical analysis.

We then present three critical figures that reveal the most important features of the analysis in each region. The first simply plots the level of the price and "quantity" variables in the model. The "quantity" variable is the actual quantity itself, or the cut-inventory ratio if that variable is used in the model. Because the inventory variables often resemble time trends, the pattern of the quantity variable would appear much like that of the cut-inventory variable. A trend in inventory simply causes the harvest pattern to rotate.

The second diagram presents a scatter plot of price against the "quantity" variable. Several years are labeled to provide insight into changes over the time dimension. If the price-quantity relationship were not affected by other variables, this set of points would in fact trace out the marginal cost curve. The rationale for this method of analysis is that supply shifts are minimal or occur slowly in short-run timber supply. Examination of this plot gives some indication of the extent to which this is true. We graph the actual levels of these variables, rather than their logarithmic transformations, because the data scales are easier to comprehend; however, in the statistical analysis we used scatter plots with the transformed variables.

The third figure presents the regression results for the equation that we have selected for the initial Pacific Rim Assessment simulations. The bottom half of the figure depicts the actual and fitted values, along with the residuals. The choice of the final equation was governed not only by model performance over the historical period, but also by recognition of the simulation properties inherent in different specifications.

A large number of regions in the model are exogenous. Chapter 9 depicts some key historical trends for three of the most important regions: Eastern USSR, Western USSR, and West Africa. Chapter 10 presents a brief summary of the estimated supply elasticities for softwood and hardwood sawtimber.

This report is a working paper in the true sense of the term. It has been prepared as a summary of our progress to date. While we had a good deal of success in modeling behavior in several regions, the results are poor and quite subjective in some cases. This paper thus serves as a useful vehicle for demonstrating both what we don't know about short-run timber supply, as well as what we do know. We hope it will stimulate discussion and comments that will improve the quality of the Pacific Rim Assessment.

2. THE WESTERN UNITED STATES

2.1 Overview

The Western U.S. is disaggregated into five regions for the Pacific Rim Assessment. Three of the regions -- Pacific Northwest Westside (PNWW), Pacific Northwest Eastside (PNWE), and Inland (IN) -- have endogenous models of timber supply. The remaining two regions -- the California Redwood region and Alaska -- are treated as exogenous.

The representation of the endogenous regions of the Western U.S. is unique because supply models are separated on the basis of ownership to reflect the different behavior of the private and public sectors. The public sector is very large in the U.S. West. In 1987, public timberland comprised 34.0 million hectares (mm ha) of the 52.4 mm ha of timberland in the U.S. West, or 65% of the total. In terms of growing stock volume on commercial timberland, public owners claim 6.42 billion m^3 of the 9.24 billion m^3 of commercial standing timber in the West, or 69%. Public ownership is dominated by the U.S. Forest Service (USFS) which controls 75% of the timberland (and 78% of the timber volume). In the private sector, the forest industry controls only 34% of the timberland (and 43% of the timber volume); however, these shares are quite variable across states ranging from 50% in the Washington and Oregon to 27% in the Rocky Mountain states. (The above information is based on data published in Haynes (1988).)

Public lands played an increasingly important role as a supplier of timber in the U.S. throughout the 1940s, 1950s, and 1960s. The USFS sold an annual average of 3.3 billion board feet (roughly 16 mm m^3) in the 1946-1950 period. Sales volumes increased rapidly though the 1950s and reached an annual average of 10.9 billion board feet in the 1961-1965 period. Sales were relatively stable subsequent to that time. (Data are taken from Weiner (1982).) In 1986, 80% of the USFS harvest occurred in the U.S. West. Reductions in future levels of public timber sales appear likely due to competing demands for production of nontimber resources: supplies of old-growth timber and old-growth habitat continue to be a critical public policy issue.

Fairly rapid reductions in forest industry softwood growing stock have characterized the last 35 years in the U.S. West. Forest industry's softwood inventory declined 31% between 1952 and 1987, and much of the decrease occurred in the larger diameter classes. Because of the transition from an old-growth to a second-growth forest, producers in the region will likely face a serious age-class gap, and increasing timber scarcity, in the coming decade. Softwood volumes on commercial public timberlands in the U.S. West (excluding Alaska due to land reclassification) have also declined. The USFS softwood inventory declined 6% from 1952 to 1987 as large decreases in Washington and Oregon more than offset the increases in the Rockies. Other public lands (again excluding Alaska) showed a 12% decrease in softwood inventory.

The U.S. West is predominantly a softwood-producing region: softwoods accounted for 91% of the growing stock in 1987. The softwood share has been gradually declining however -- it was 94% in 1962 -- due to the drawdown in softwood inventories in the Pacific Northwest and California coupled with an increase in the hardwood growing stock in all subregions. Douglas-fir is the predominant softwood species (accounting for 30% of the 1987 volume), followed by pines (22%, including ponderosa, jeffrey, lodgepole, western white, and sugar), true firs (14%), western hemlock (13%), and spruces (11%). The hardwoods are comprised primarily of cottonwood and aspen (29%), red alder (27%), and oak (21%).

Lumber and plywood producers are by far the dominant consumers of timber in the U.S. West. In the coastal regions, log exports also are a very important use of raw materials. Timber harvests for pulpwood are significant in the Pacific Northwest Westside, but are of limited importance elsewhere in the West. Miscellaneous uses are quite small throughout the region. Fuelwood is ignored, because much of the small volume that is harvested is taken from nongrowing stock sources.

Supply models for the U.S. West are specified to accommodate the special provisions concerning the sale of public timber. Sales levels in any year are set by the governing agency, and, at least in the case of the USFS, sales levels are not influenced by price. Potential purchasers bid for timber and the contract is awarded to the highest bidder. Specific contracts may be quite variable, but purchasers generally have several years to actually harvest the timber. In the 1970s, lags between bid and harvest were quite long, sometimes as much as seven years. Thus, at any point in time, considerable volumes of timber are under contract and can be harvested at the discretion of the contracts' owners. This market behavior suggests that the actual amount of timber harvested from public lands in any year should respond to current prices.

All of the models for U.S. West are for softwoods only. Sawtimber models incorporate stumpage prices and harvest and delivery costs separately. The estimated sawtimber equations presented in this section refer exclusively to stumpage prices. For all of the U.S. West regions, harvest and delivery costs for sawtimber are projected exogenously.

2.2 Pacific Northwest Westside

The Pacific Northwest Westside (PNWW), sometimes referred to as the Douglas-fir region or the Coastal region, is defined as Western Washington and Western Oregon, that is Washington and Oregon west of the crest of the Cascade mountains. Relative to its small size (9.5 mm ha of commercial timberland), the region is a comparatively large timber producer (approximately 91 mm m^3 of softwood timber were harvested in 1987). Softwood lumber and plywood manufacturers consumed 62% of the region's harvest. Softwood log exports amounted to 17%. Softwood roundwood pulpwood totaled 14%, while the balance was consumed in miscellaneous uses.

Data on timber harvests are derived from estimates of product output, with appropriate adjustments made for foreign trade. Public cut is the scaled level of removals from sales harvested in the indicated year. Private cut is defined as the difference between the total harvest and the reported level of public harvest. In 1987, the private sector accounted for approximately 2/3's of the softwood sawtimber harvest.

Public and private sawtimber harvests are split from pulpwood harvests by the following procedure. The level of roundwood pulpwood harvest in the region is inferred by subtracting residue production associated with lumber and plywood operations from the sum of pulpwood consumption at pulp mills plus chip exports. Sawtimber harvests on public and private lands are then estimated by assuming that the pulpwood cut on each ownership occurs in the same proportions as the total harvest.

2.2.1 Private Softwood Sawtimber Supply

Figure 2.1 depicts the real sawtimber harvest price and the cut-inventory ratio for the PNWW. The price is expressed in 1980 USD/m^3 and measures the average price of stumpage harvested from USFS lands including all convertible products. The price of USFS timber is assumed to be a reasonable proxy for private timber due to the existence of arbitrage opportunities. The cut variable reflects private sawtimber exclusively, while the inventory data measure the total private growing stock volume.

Sawtimber stumpage prices rose sharply from the early 1960s to their 1977-1979 peak, and collapsed in the early 1980s. By 1987, a modest rebound in real prices had become apparent. The harvesting pattern mirrored this pattern quite well: the cut-inventory ratio rose from less than 3% in the early 1960s to exceed 5% in the late 1970s. However, the relative magnitude of the decrease in the cut-inventory ratio in the early 1980s was smaller than the price drop, and by 1987, the cut-inventory ratio was at the highest level that we have observed since 1960.

A scatter plot showing the relationship between the stumpage harvest price and the cut-inventory ratio is shown in *Figure 2.2*. The relationship between the two variables is clear, as is the obvious structural shift that occurred since 1982.

The final equation is shown in *Figure 2.3*. An intercept dummy for 1982-1987 is used for the structural shift. Alternative models were tested, including specifications which allowed for a slope shift in the 1980s. However, the results of these more complicated models did not differ materially from the final equation. The elasticity of private sawtimber stumpage supply with respect to the harvest price is 0.72.

2.2.2 Public Softwood Sawtimber Supply

The price variable in the public sawtimber stumpage supply model is the ratio of the current harvest price to a three-year moving average of past sales prices, all expressed in nominal USD/m^3. The quantity variable in the model is the ratio of public sawtimber harvests to the uncut volume of timber under contract at the end of the prior year. The rationale for this specification is that the price for public timber is a function of past bid prices, and that as the share of timber under contract which is cut increases, its cost rises as well.

Figure 2.4 shows that the price ratio fell sharply in the early 1980s which resulted from the combination of high bid prices in the late 1970s and low market prices for timber in the early 1980s. The harvest of timber from the volume available under contract also fell sharply during the early 1980s since manufacturers could not afford to process high-cost wood purchased in previous years. The scatter plot in *Figure 2.5* demonstrates the relationship between these two variables. As with private timber, an obvious structural shift characterizes the data in recent years. The final equation is shown in *Figure 2.6*. The elasticity of public sawtimber supply with respect to harvest price is 1.27, which is significantly higher than that observed for the private sector.

Two additional equations are needed to complete the public timber supply model. The real sales price is modeled simply as a function of past real product prices. Attempts to add a variable to reflect supply tightness (for example, the ratio of timber sold to the uncut inventory under contract) were unsuccessful. The elasticity of the sales price with respect to past product prices is 0.42.

A model of uncut inventory under contract also must be constructed. In theory, a simple inventory accounting identity would be appropriate, where the uncut inventory is equal to the uncut inventory in the previous period plus this period's sales less this period's harvest. However, due to scaling errors, defaults on contracts, differences in reporting dates, and possibly other factors, this identity fails to hold. However, efforts to model this process were unsuccessful so we have retained the accounting identity for future periods.

2.2.3 Softwood Pulpwood Supply

Pulpwood supply in the PNWW is important to our modeling effort for three reasons: 1) pulpwood supply constitutes a significant portion of the roundwood harvest in the region and thus is important in the timber inventory model; 2) chip revenue is an important source of income for lumber and plywood manufacturers in the region; and, 3) chip exports themselves are an important item in international trade for this region.

The price variable is the real average unit value of chips exported from Washington and Oregon; hence, this price is used to proxy for the average price of pulpwood received at a consumption point. The price is measured in 1980 USD/m^3. The quantity variable is the harvest of roundwood for pulp production. (The rationale for using roundwood, as opposed to all pulpwood including chips, is provided in Section 3.2.3.) Attempts to include an inventory term in this model were unsuccessful. Both variables are depicted in *Figure 2.7*, and a scatter plot is shown in *Figure 2.8*. The final equation (*Figure 2.9*) was estimated over the period 1969 to 1987, with a dummy for 1974. The earlier period of apparently perfectly elastic supply (1965-1968) was eliminated as irrelevant to the future. The elasticity of roundwood pulpwood supply with respect to the delivered pulpwood price is 2.70.

2.3 Pacific Northwest Eastside

The Pacific Northwest Eastside (PNWE) is defined as Eastern Washington and Eastern Oregon. Though the timberland area is about 80% of the size of the Westside, the softwood harvest is less than 20% of the Westside volume. Softwood lumber and plywood manufacturers consume essentially the entire region's harvest, with lumber accounting for nearly 90%.

Data on timber harvests are derived from estimates of product output. Public cut is the scaled level of removals from sales harvested in the indicated year, and private cut is defined as the difference between the total harvest and the reported level of public harvest. In contrast to the Westside, public timber supplies are dominant on the Eastside, accounting for nearly 2/3's of the harvest in recent years.

2.3.1 Private Softwood Sawtimber Supply

Figure 2.10 depicts the real sawtimber harvest price and the cut-inventory ratio. The price and cut variables are defined in the same manner as the Westside: the price is in 1980 USD/m^3 and measures the average stumpage price of timber harvested from USFS lands including all convertible products; the cut variable reflects private sawtimber exclusively, while the inventory data measure the total private growing stock volume.

As expected, sawtimber stumpage prices follow much the same pattern as on the Westside, rising sharply from the early 1960s to their 1977-1979 peak, collapsing in the early 1980s, and rebounding by 1987. However, the harvesting pattern contrasts sharply with the Westside. There has been a distinct decline in the cut-inventory ratio from 1960 to 1987: the ratio exceeded 4% in 1960 and currently averages about 2-2.5%.

A scatter plot showing the relationship between stumpage harvest price and the cut-inventory ratio is shown in *Figure 2.11*. There is no clear explanation for the curious pattern observed in the scatter plot from 1960 to 1973. Hence this period was eliminated from the estimation of the final equation. The regression results are shown in *Figure 2.12*, and the elasticity of private sawtimber stumpage supply with respect to the harvest price is 1.05.

2.3.2 Public Softwood Sawtimber Supply

The variables for the public sawtimber stumpage supply model are defined in the same manner as for the Westside. *Figures 2.13* and *2.14* show "price-quantity" levels and the scatter plot depicting the relationship between the two relevant variables. The final equation, shown in *Figure 2.15*, indicates that the elasticity of public sawtimber supply with respect to harvest price is 0.85. Thus, unlike the Westside, public supply is less elastic than private supply, though the difference is not significant.

The bid price equation indicates that elasticity of the real sales price with respect to past real product prices is 0.54. The model of uncut volumes under contract works reasonably well. A regression including the appropriate variables in the accounting identity yields parameter estimates that are not significantly different from their expected values. The accounting identity is used for future periods.

2.4 The Inland Region

The Inland Region of the U.S. is defined as the Rocky Mountain states plus Inland California (California less the Redwood Region). The timberland area is three times as large as the PNWW, but the softwood harvest is only about 40% as large. Softwood lumber manufacturers consume the vast majority of the region's harvest.

Public and private timber supplies are more evenly distributed than in the two subregions of the Pacific Northwest. In 1987, the public sector accounted for about 55% of the harvest.

In the following sections, the variables in the private and public sawtimber stumpage supply models are defined in the same way as for the PNWE.

2.4.1 Private Softwood Sawtimber Supply

Figure 2.16 depicts the real sawtimber harvest price and the cut-inventory ratio. While the peaks in real stumpage prices are similar in the early- and late-1970s, price levels in the Inland region are significantly lower than in the Pacific Northwest. The harvest pattern is quite erratic, but appears relatively stable over the long term. The cut-inventory ratio ranges between 1% and 2% and thus is quite low relative to the Pacific Northwest.

Figure 2.17 presents the harvest price plotted against the cut-inventory ratio. The relationship is not nearly as well-behaved as in the Pacific Northwest subregions. The 1960-1968 period was eliminated from the estimation sample. Based on an examination of the scatter plot and behavior observed in other regions, a structural shift was assumed to have occurred in the 1984-1987 period. The regression results are shown in *Figure 2.18*, and the elasticity of private sawtimber supply with respect to the harvest price is 0.79.

2.4.2 Public Softwood Sawtimber Supply

The statistical analysis of public softwood sawtimber supply for the U.S. Inland region is shown in *Figures 2.19-2.21*. *Figure 2.19* demonstrates "price-quantity" levels and the scatter plot depicting the relationship between the two relevant variables is shown in *Figure 2.20*. The final equation is presented in *Figure 2.21*. As with the PNWW, a dummy variable was needed for the 1984 to 1987 period. The elasticity of public sawtimber supply with respect to harvest price is 0.47, which is quite low compared to other regions in the U.S. West.

The bid price equation indicates that elasticity of the real sales price with respect to past real product prices is 0.49. As in the case of the PNWE, the estimated coefficients for the accounting identity do not differ significantly from the values expected, and the theoretical accounting identity is used for future periods.

Figures 2.1-2.3: **Pacific Northwest Westside, Private Lands - Softwood Sawtimber**: Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 2.1 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

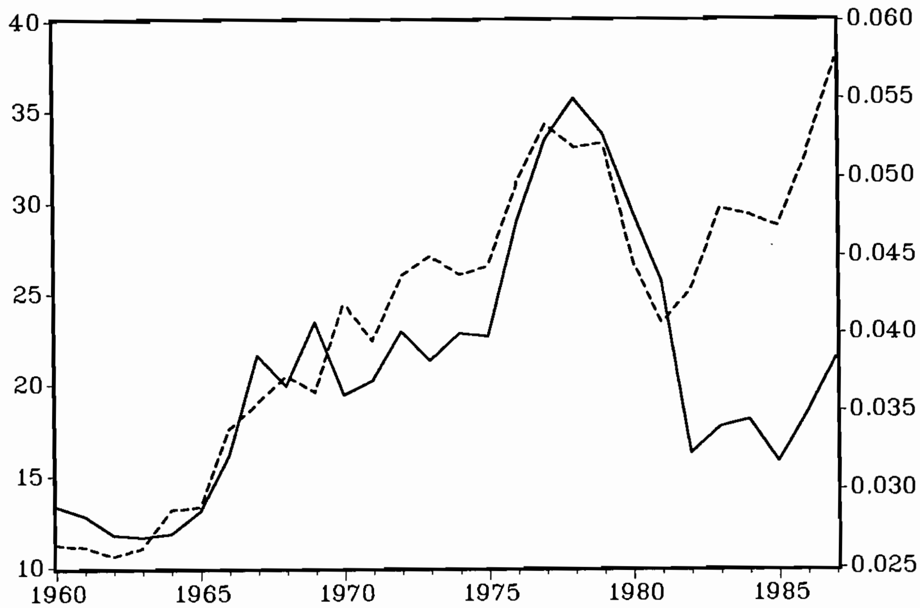


Figure 2.2 Scatter plot of **P** against **CI**

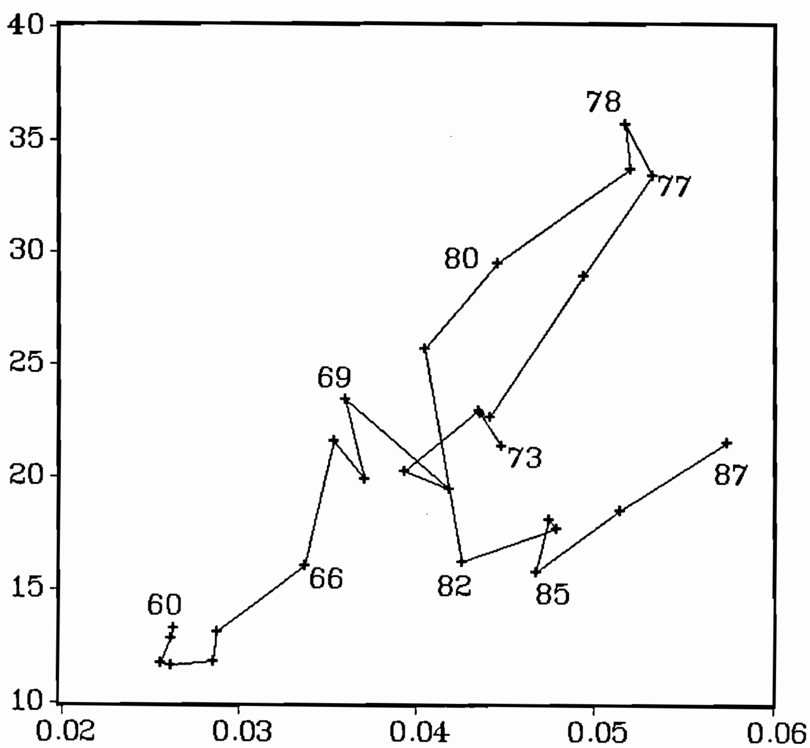


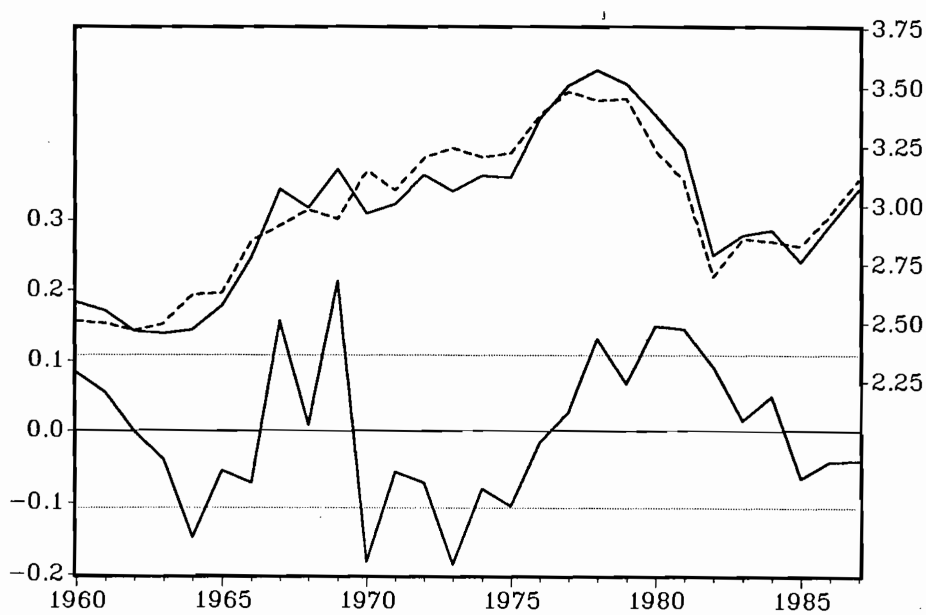
Figure 2.3 Regression results and plot of residual, actual, and fitted values

```
LS // Dependent Variable is LN (P)
SMPL range: 1960  -  1987
Number of observations: 28
```

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7.5710646	0.3097326	24.443872	0.000
LN (CI)	1.3940786	0.0942956	14.784134	0.000
D8287	-0.4787886	0.0550235	-8.7015334	0.000

R-squared	0.899893	Mean of dependent var	2.978154
Adjusted R-squared	0.891884	S.D. of dependent var	0.326704
S.E. of regression	0.107423	Sum of squared resid	0.288494
Durbin-Watson stat	1.362386	F-statistic	112.3663
Log likelihood	24.32370		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 2.4-2.6: **Pacific Northwest Westside, Public Lands - Softwood Sawtimber:** Relationship between stumpage price at harvest (**P**) in USD/m^3 divided by moving average of sales prices (**PS**) in USD/m^3 and ratio of cut to uncut volume under contract (**CU**)

Figure 2.4 Historical trends in **P/PS** (solid line, left axis) and **CU** (dashes, right axis)

Figure 2.5 Scatter plot of **P/PS** against **CU**

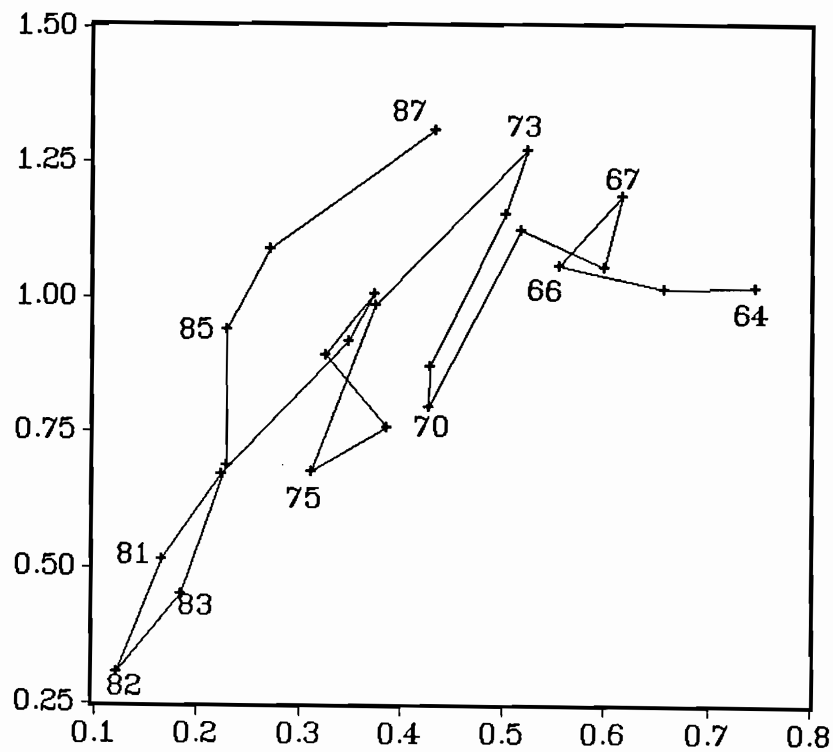


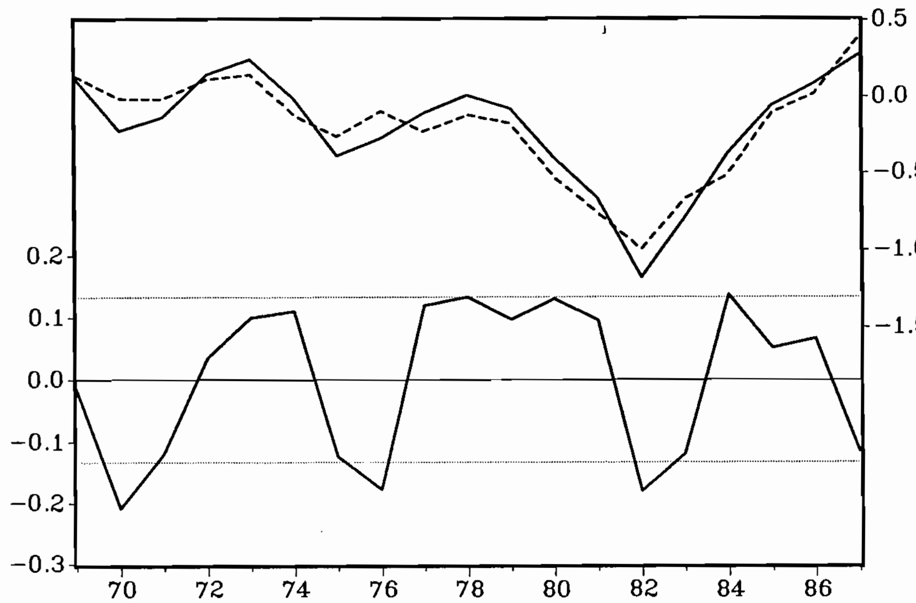
Figure 2.6 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN [P / AVG(PS_{-1} + PS_{-2} + PS_{-3})]
SMPL range: 1969 - 1987
Number of observations: 19

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.6493021	0.0939177	6.9135190	0.000
LN (CU)	0.7887606	0.0761554	10.357249	0.000
D8587	0.3952657	0.0836429	4.7256311	0.000

R-squared	0.887003	Mean of dependent var	-0.204121
Adjusted R-squared	0.872879	S.D. of dependent var	0.372525
S.E. of regression	0.132820	Sum of squared resid	0.282260
Durbin-Watson stat	1.455827	F-statistic	62.79841
Log likelihood	13.02914		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 2.7-2.9: **Pacific Northwest Westside, All Lands - Softwood Roundwood Pulpwood:** Relationship between delivered price (**P**) in 1980 USD/m^3 and cut in million m^3 (**Q**)

Figure 2.7 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

Figure 2.8 Scatter plot of **P** against **Q**

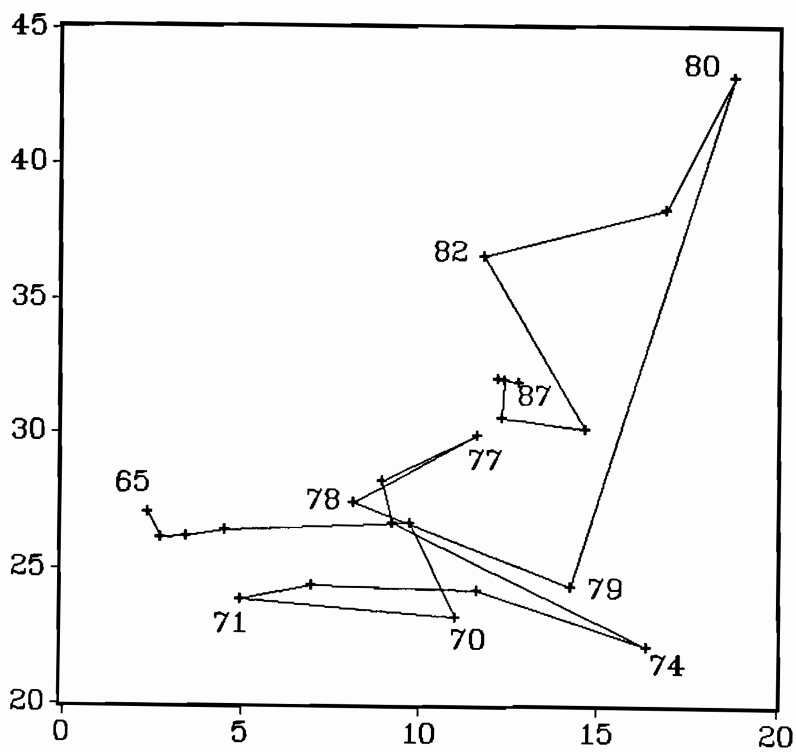


Figure 2.9 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1969 - 1987
Number of observations: 19

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.4828326	0.2520097	9.8521304	0.000
LN (Q)	0.3698298	0.1037303	3.5653026	0.003
D74	-0.4216194	0.1444463	-2.9188659	0.010

R-squared	0.511058	Mean of dependent var	3.359510
Adjusted R-squared	0.449941	S.D. of dependent var	0.182028
S.E. of regression	0.135003	Sum of squared resid	0.291612
Durbin-Watson stat	2.279800	F-statistic	8.361871
Log likelihood	12.71950		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis

Figures 2.10-2.12: **Pacific Northwest Eastside, Private Lands - Softwood Sawtimber:** Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 2.10 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

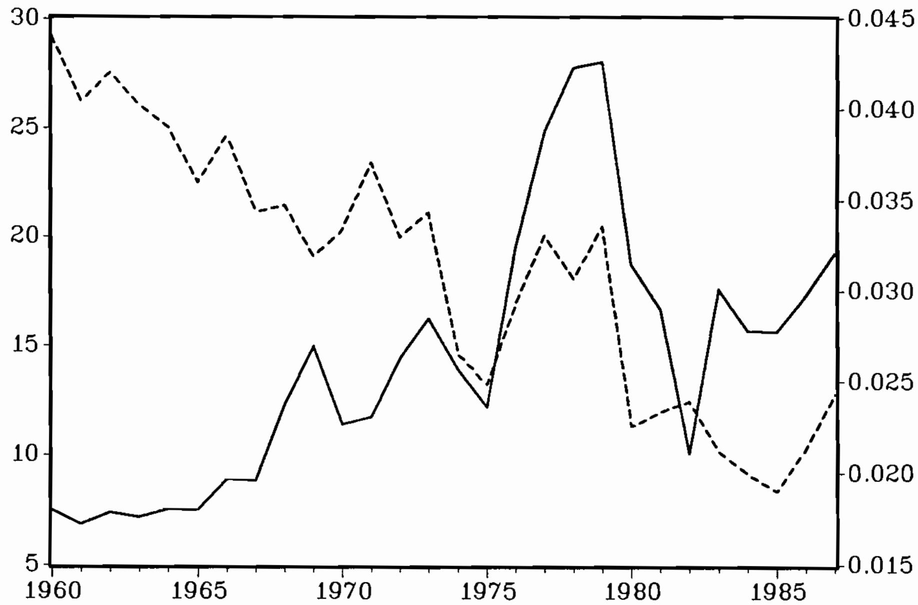


Figure 2.11 Scatter plot of **P** against **CI**

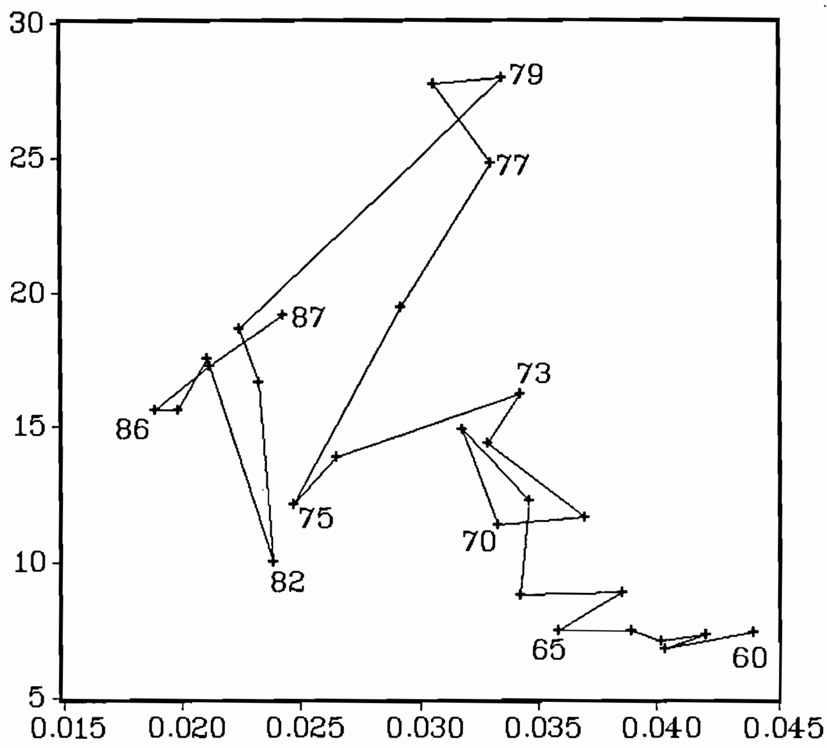


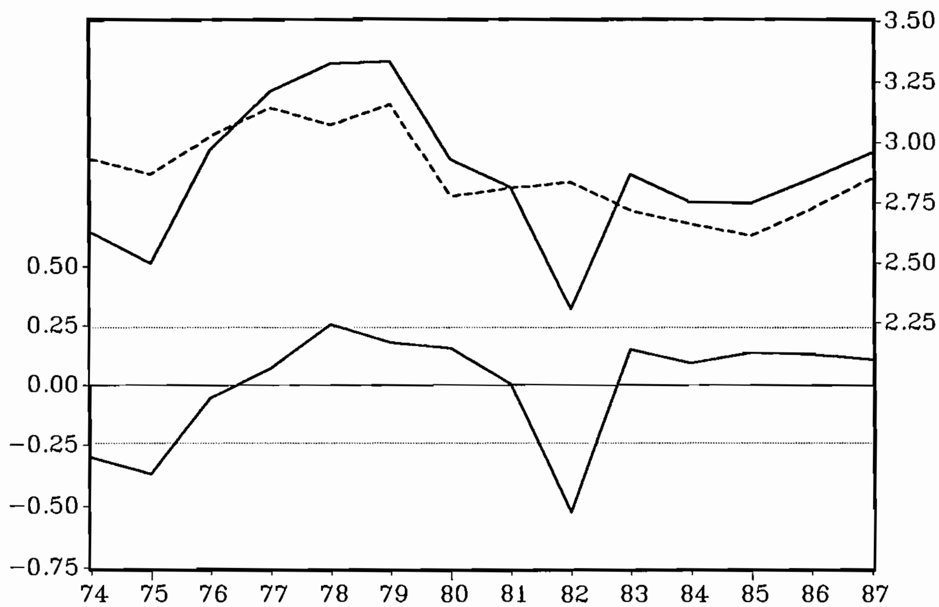
Figure 2.12 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1974 - 1987
Number of observations: 14

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	6.3853920	1.3639897	4.6814078	0.001
LN (CI)	0.9512793	0.3686350	2.5805457	0.024

R-squared	0.356886	Mean of dependent var	2.869551
Adjusted R-squared	0.303293	S.D. of dependent var	0.291307
S.E. of regression	0.243151	Sum of squared resid	0.709467
Durbin-Watson stat	1.305935	F-statistic	6.659216
Log likelihood	1.010950		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 2.13-2.15: **Pacific Northwest Eastside, Public Lands - Softwood Sawtimber:** Relationship between stumpage price at harvest (**P**) in USD/m^3 divided by moving average of sales prices (**PS**) in USD/m^3 and ratio of cut to uncut volume under contract (**CU**)

Figure 2.13 Historical trends in **P/PS** (solid line, left axis) and **CU** (dashes, right axis)

Figure 2.14 Scatter plot of **P/PS** against **CU**

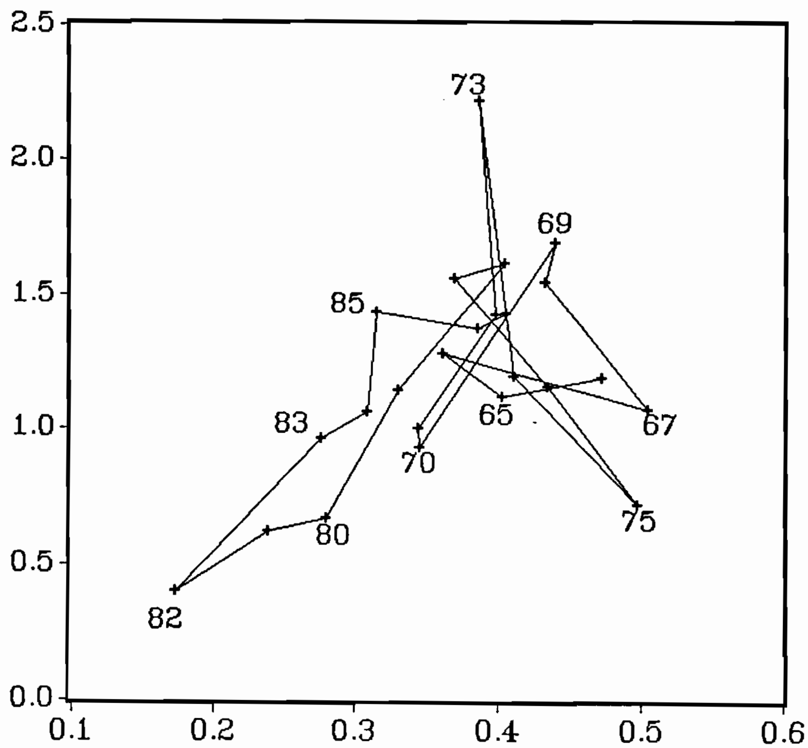


Figure 2.15 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN [P / AVG(PS_{-1} + PS_{-2} + PS_{-3})]
SMPL range: 1964 - 1987
Number of observations: 24

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1.3445519	0.2250115	5.9754797	0.000
LN (CU)	1.1699605	0.2136014	5.4773071	0.000
D75	-0.8621351	0.2554783	-3.3745927	0.003

R-squared	0.616345	Mean of dependent var	0.123273
Adjusted R-squared	0.579807	S.D. of dependent var	0.370721
S.E. of regression	0.240310	Sum of squared resid	1.212729
Durbin-Watson stat	1.867756	F-statistic	16.86837
Log likelihood	1.767647		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis

Figures 2.16-2.18: **U.S. Inland Region - Softwood Sawtimber:** Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 2.16 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

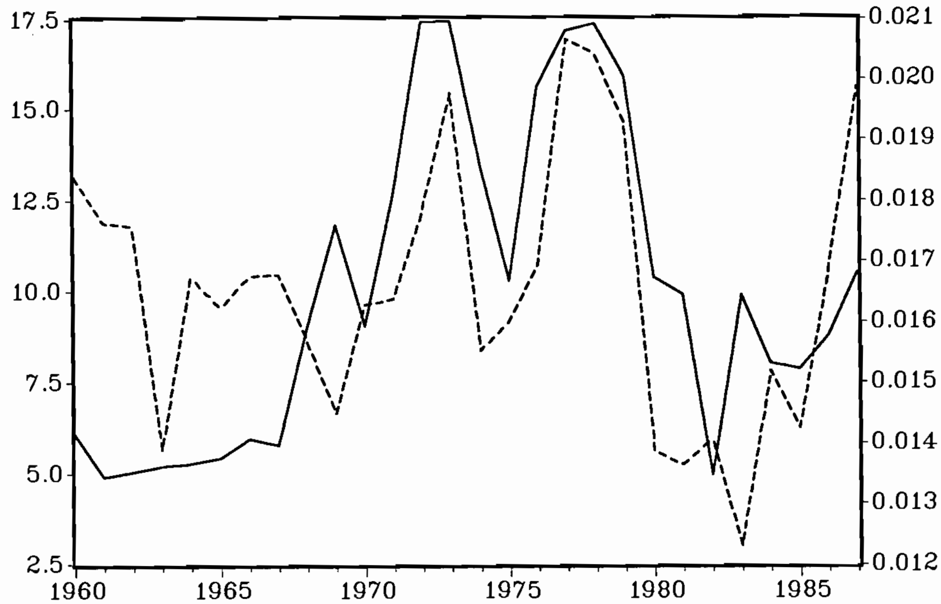


Figure 2.17 Scatter plot of **P** against **CI**

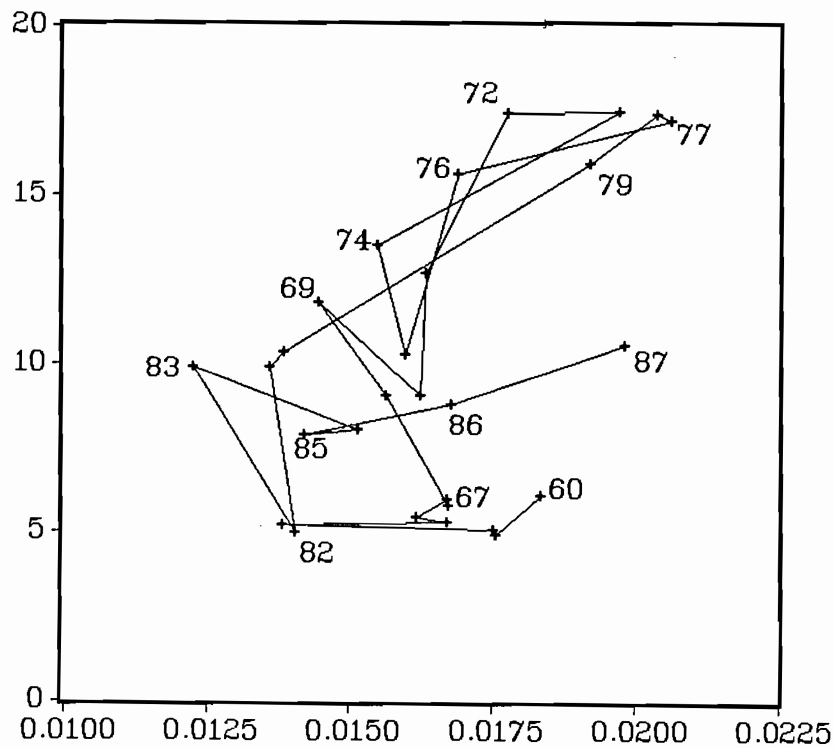


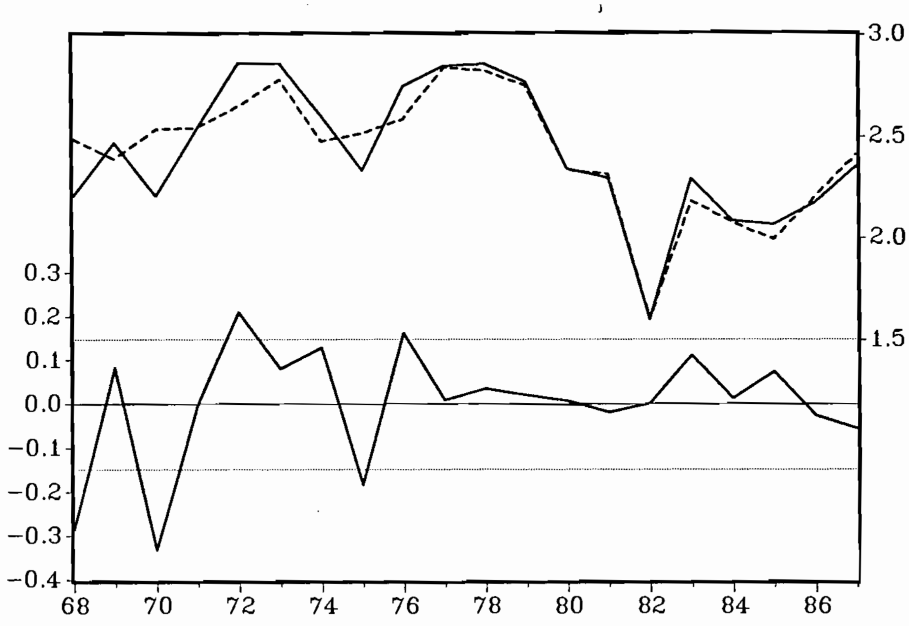
Figure 2.18 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1968 - 1987
Number of observations: 20

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7.7328962	0.9630716	8.0294096	0.000
LN (CI)	1.2620896	0.2341312	5.3905232	0.000
D82	-0.7534513	0.1571549	-4.7943225	0.000
D8487	-0.3772315	0.0833585	-4.5254136	0.000

R-squared	0.837184	Mean of dependent var	2.422447
Adjusted R-squared	0.806656	S.D. of dependent var	0.336884
S.E. of regression	0.148131	Sum of squared resid	0.351085
Durbin-Watson stat	2.168168	F-statistic	27.42340
Log likelihood	12.04581		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 2.19-2.21: **U.S. Inland Region, Public Lands - Softwood Sawtimber:** Relationship between stumpage price at harvest (**P**) in USD/m^3 divided by moving average of sales prices (**PS**) in USD/m^3 and ratio of cut to uncut volume under contract (**CU**)

Figure 2.19 Historical trends in **P/PS** (solid line, left axis) and **CU** (dashes, right axis)

Figure 2.20 Scatter plot of **P/PS** against **CU**

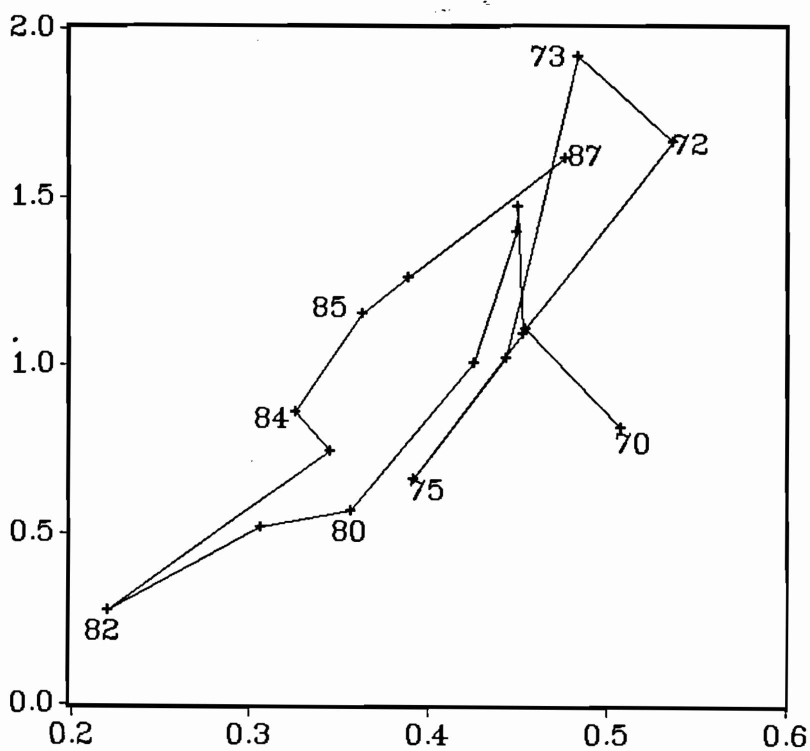


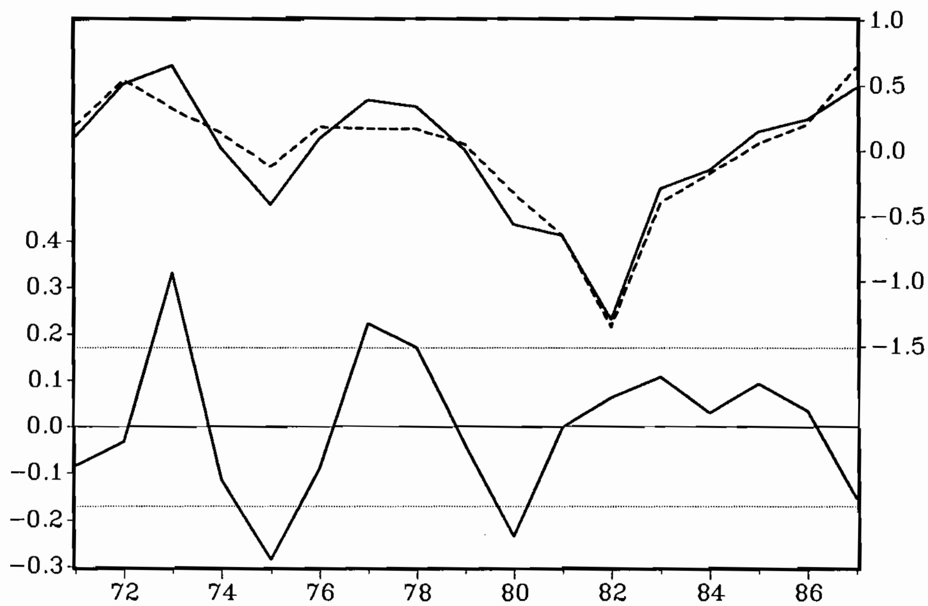
Figure 2.21 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN [P / AVG(PS_{-1} + PS_{-2} + PS_{-3})]
SMPL range: 1971 - 1987
Number of observations: 17

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1.8687726	0.1876348	9.9596292	0.000
LN (CU)	2.1364918	0.1985461	10.760683	0.000
D8487	0.3420994	0.0975803	3.5058230	0.003

R-squared	0.897833	Mean of dependent var	-0.023805
Adjusted R-squared	0.883237	S.D. of dependent var	0.497981
S.E. of regression	0.170163	Sum of squared resid	0.405375
Durbin-Watson stat	1.708187	F-statistic	61.51509
Log likelihood	7.635373		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



3. THE EASTERN UNITED STATES

3.1 Overview

The U.S. East is divided into two subregions, the South and the North. Timber supply in the U.S. East is distinguished from other regions by the importance of both softwood and hardwood markets and both sawtimber and roundwood pulpwood markets. No distinctions are drawn between public and private timber supply in the U.S. East because of the relatively small share of public ownership.

The most salient feature of Eastern U.S. timber markets is the dramatic growth in timber inventory in all regions and for all ownerships. This has occurred in the South in spite of the fact that timberland area declined from 82.8 mm ha in 1952 to 79.1 mm ha in 1987. There has been virtually no change in the total Northern area (62.6 mm ha); however, aggregate statistics conceal very divergent trends in the North. The Northeast and North Central regions contain roughly equivalent areas of timberland, but Northeast timberland area increased 10% over the past 35 years, while the North Central region declined 8%. (This information is based on data available in Haynes (1988).)

The softwood growing stock in the U.S. East has increased about 75% between 1952 and 1987. Although the South currently has more than twice the volume of softwoods as the North (2.94 billion m^3 compared to 1.34 billion m^3), the percentage increases have been comparable across the two regions. The rate of increase in inventory growth has slowed dramatically during the past decade.

Though softwoods are commercially more important than hardwoods in the U.S. East, the hardwood growing stock is substantially larger (hardwood volumes total 7.76 billion m^3, whereas softwood volumes amount to 4.28 billion m^3). The region's hardwood inventory has increased about 70% since 1952, with the North registering moderately higher increases. Hardwood volumes are approximately the same in the South and North.

Forest management practices among nonindustrial forest landowners have been a continuing concern for the forest products industry, particularly in the South. Nonindustrial private landowners own 64% of the softwood growing stock in the South (compared to 23% for the forest industry), and 76% of the hardwood growing stock (the forest industry owns only 13%). For the North, the comparable figures for softwoods are 53% nonindustrial private and 23% industrial, and for hardwoods the figures are 70% nonindustrial private, and 9% industrial. The failure of nonindustrial landowners to regenerate pine species has led to natural hardwood succession and threatened the potential softwood supply in this region. However, the problem has been partially mitigated by the extensive development of plantations on forest industry lands. In 1985, 8.5 mm ha of timberland in the South (about 11% of total timberland) was classified as plantations. There was a relatively high concentration of plantations on forest industry lands (31%), while 6% of public lands were plantations, and 5% of nonindustrial private lands. While pine plantations contained only 13% of the southern softwood inventory in 1985, and provided 13% of the softwood harvest, these shares will rise substantially in the future.

The softwood growing stock in the U.S. East is predominantly pines, spruce and balsam fir, but the mix varies substantially across regions. In the South, 91% of the softwoods are yellow pines. In the North, yellow pines constitute only 6% of the softwood growing stock, with the bulk comprised of spruce and balsam fir (37%), and white, red, and jack pines (29%). Eastern hemlock also accounts for a significant fraction of the northern softwood growing stock (14%).

The hardwood growing stock in the U.S. East consists primarily of oaks and maples. In the South, white and red oaks make up 44% of the hardwood growing stock, while maples constitute 6%. White and red oaks comprise 28% in the northern hardwood inventory, and maples account for 25%. Other important species are sweetgum, yellow poplar, tupelo, black gum, and hickory in the South, and cottonwood, aspen, ash, beech, and yellow poplar in the North.

The South is a large producer of softwood sawlogs and veneer logs and softwood roundwood pulpwood, and production levels dwarf those of the North. The South produced 81.5 mm m^3 of softwood sawlogs and veneer logs in 1987, compared to 10.9 mm m^3 in the North; southern softwood roundwood pulpwood production reached 61.6 mm m^3 in 1987, compared with northern production of only 9.0 mm m^3. Hardwood production is more closely balanced between the South and North. The two subregions produce roughly equal volumes of sawlogs and veneer logs (about 22 mm m^3 in 1987). However, the South currently produces 30 mm m^3 of hardwood roundwood pulpwood, which is twice the production of the North.

While timber quality and lumber grades are believed to be important in understanding hardwood lumber production, consumption, and prices, it is not feasible to carry the detail necessary to account for these distinctions in the Pacific Rim Assessment. The approach we use to model sawtimber supply is thus similar for hardwoods and softwoods. Sawtimber models for the U.S. East incorporate stumpage costs and harvest and delivery costs separately. The estimated sawtimber equations presented in this section refer exclusively to stumpage prices. Forecasts of sawtimber harvest and delivery costs are determined exogenously. Models of pulpwood are on a delivered basis.

3.2 The South

The South, or Southern Pine region, is defined as the following 12 southern states: Virginia, North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas.

3.2.1 Softwood Sawtimber Supply

The harvest of softwood sawlogs and veneer logs has increased rapidly over the last two decades. The growth has been spurred by strong growth rates in lumber production and spectacular growth rates by the plywood sector. Log exports (and imports) are negligible. Log usage in softwood lumber production grew from 31.2 mm m^3 to in 1962 to 58.1 mm m^3 in 1987: the growth rate was 86% and the volume increase was 26.9 mm m^3. Southern softwood plywood producers consumed 23.4 mm m^3 of veneer logs in 1987, whereas there were no plywood mills operating in the South in 1962. Lumber production now accounts for about 70% of softwood sawlog/veneer log consumption.

Data on sawtimber harvests are derived from estimates of lumber and plywood output. Here we reiterate a point made in Section 1.3: logs defined as sawlogs on the basis of size and grade are excluded if they are consumed in pulp production. This distinction is particularly important for the South. The USFS estimated that 27% of the sawtimber consumed in the South in 1976 was consumed in pulp production (USDA, FS, 1982, Table 3.56).

Our definition of the quantity variable raises an important methodological issue. Recent work by Brannlund (1988), Kuuluvainen (1988), and Newman (1987) has emphasized the importance of including pulpwood price in the sawtimber equation in regions where sawtimber and pulpwood are produced in large volumes. The rationale for the pulpwood price in the short-run specification is that competition at the margin will cause shifts between end uses: sawlogs/veneer logs will be diverted from sawmills and plywood mills to pulp mills when pulpwood prices are high. But there also are strong theoretical reasons to anticipate the opposite effect: when chip prices are high, more sawlogs may be produced because changing relative prices make reduced lumber and plywood recovery profitable. An additional point is that if product definitions are altered so that sawtimber harvests are defined from the supply side (on the basis of size and grade), then high chip prices should also lead to increased sawtimber production as more larger-diameter trees are harvested for pulpwood.

A serious statistical trap also must be recognized in the specification including pulpwood prices. When lumber and plywood production decline, sawtimber harvests and chip production (generated as manufacturing residues) both decrease. The two series generally are highly correlated so that reduced sawtimber harvests lead to higher pulpwood prices, all else equal. These changes in the chip market could produce the hypothesized relationship of rising pulpwood prices associated with declining sawtimber supplies, and hence would be spurious correlation. For both theoretical and statistical reasons, we chose not to include the pulpwood price in the sawtimber supply equation.

There are several price series available to measure southern softwood sawtimber prices. We have chosen average prices available from Timber Mart South (TMS) as being most representative for the region. Since the TMS price is available only since 1977, the series was backcasted based on annual percentage changes in the relevant Louisiana state prices.

Figure 3.1 depicts the real sawtimber stumpage price in 1980 USD/m^3 and the cut-inventory ratio. The cut variable is defined above and the inventory variable includes the total softwood growing stock in the South. Real sawtimber stumpage prices rose rapidly from the early 1960s to their 1979 peak, and subsequently declined; however, in relative terms, the decrease was much smaller than we observed in the U.S. West. The harvesting pattern mirrored the price pattern reasonably well until 1980, and during this period the cut-inventory ratio reached a peak of 2.5% in 1979. However, though real prices have stayed low throughout the 1980s, the cut-inventory has continued to climb sharply and now registers 3.2%.

A scatter plot showing the relationship between stumpage price and the cut-inventory ratio is shown in *Figure 3.2*. There is a clear relationship between these two variables in the 1962 to 1982 period. From 1983 onward, there is an outward shift in cut-inventory levels without much movement in real prices. Some analysts attribute this shift to salvage operations that were necessary due to widespread southern pine beetle attacks. For modeling purposes, these changes are captured simply by using individual dummies for each year. Significant serial correlation was present in the ordinary least squares model. Correction of this problem nearly doubles the estimate of the supply elasticity. The final equation and its fit is shown in *Figure 3.3*. The elasticity of softwood sawtimber supply with respect to the stumpage price is 0.68, which is remarkably close to that of private sawtimber suppliers in the Pacific Northwest Westside.

3.2.2 Hardwood Sawtimber Supply

Data on sawtimber harvests are derived from estimates of lumber and plywood output. Measurement of hardwood lumber production in the U.S. is poor, and hence these data are subject to large measurement errors. Thus, we first consider national trends before turning to the South.

For estimates of national hardwood lumber production, we use the data developed for the Hardwood Assessment Market Model (see Cardellichio and Binkley (1984) for documentation). These data indicate that the consumption of hardwood logs in lumber manufacturing has risen from 32.4 mm m^3 in 1960 to 41.4 mm m^3 in 1987, a 28% increase. In contrast, hardwood plywood production has fallen significantly over time. Log consumption was estimated to be 4.4 mm m^3 in 1960 and only 1.8 mm m^3 in 1987. Thus, hardwood veneer log consumption is currently less than 5% of total hardwood sawlog and veneer log consumption.

The national production data were regionalized as follows. Lumber production was allocated between the South and North on the basis of U.S. Bureau of Census production shares. The shares are approximately equal and have been reasonably stable over time; however, these data should be treated with much skepticism. Plywood production was simply divided evenly between the two regions for three reasons: 1) much of the production occurs at the border of the two regions (political boundaries do not provide a very useful regional division for the hardwood plywood sector); 2) regional production data are not readily available (and may not exist); and, 3) log usage by the plywood sector is negligible relative to lumber.

There are multiple price series available to measure southern hardwood sawtimber prices. For the period 1960-1976 we use a volume-weighted average of hardwood stumpage prices in Louisiana. For 1977-1987, we update this series using percentage changes from the TMS mixed hardwood series.

Figure 3.4 depicts the real hardwood sawtimber stumpage price in 1980 USD/m^3 and the cut-inventory ratio. The cut variable is defined above and the inventory variable includes the total hardwood growing stock in the South. Real sawtimber stumpage prices climbed quickly from 1960 to 1973. Since that time they have demonstrated significant cyclical fluctuations, but returned to the level of the 1973 peak in 1978 and again in 1984-1986. The cut-inventory ratio indicates clear cyclical patterns, but exhibits a decidedly downward trend over the historical period. Currently, less than 0.7% of the southern hardwood inventory is being harvested for lumber and plywood production. Although the hardwood sawlog/veneer harvest has been increasing significantly over time, it has not kept pace with the rapid growth in the timber inventory.

The relationship between stumpage price and the cut-inventory ratio is shown in the scatter plot in *Figure 3.5*. The relationship is rather curious and does not demonstrate the expected behavior between price and quantity. A large proportion of southern hardwood sawtimber is owned by nonindustrial private landowners and theoretical and empirical models using microdata have both suggested that income is an important variable in the harvest decision of the nonindustrial private landowner. For these reasons, we include real disposable personal income as a supply shifter in this model. For estimation purposes, we eliminated the 1960-1967 period from the sample. The final equation is presented in *Figure 3.6*. The equation generally reproduces the major turning points, but it fits the data poorly. The elasticity of hardwood sawtimber supply with respect to the stumpage price is 1.65.

3.2.3 Softwood Pulpwood Supply

Softwood pulpwood consumption in the South increased from 52.0 mm m^3 in 1965 to 101.2 mm m^3 in 1987. Although total wood furnish nearly doubled over this period, roundwood pulpwood consumption increased only 45%, from 42.4 mm m3 in 1965 to 61.6 mm m3 in 1987. The roundwood share decreased as wood residue generation increased at lumber and plywood plants, and residue utilization improved as well. The theoretical model chosen for pulpwood supply assumes that residue availability and consumption is determined as a fixed proportion of lumber and plywood output. Thus, roundwood supply is the appropriate variable in the pulpwood model. An inventory term was not included because it did not improve the fit of the equation, and it is difficult to interpret when prices are measured at the point of consumption.

There are several measures of pulpwood prices available. Based on examination of available series, we chose the average price of Southeast and South Central residue prices, measured in 1980 USD/clean green ton delivered to the pulp mill. The price and quantity variables are plotted in *Figure 3.7*. The scatter plot shown in *Figure 3.8* indicates the relationship is reasonably well-behaved. The final equation (*Figure 3.9*) was estimated over the period 1965 to 1986. The elasticity of roundwood pulpwood supply with respect to the delivered pulpwood price is 2.54. Again we note that this is remarkably similar to the comparable elasticity estimated for the Pacific Northwest Westside (2.70).

3.2.4 Hardwood Pulpwood Supply

Hardwood pulpwood supply in the South was analyzed in the same fashion as softwood pulpwood supply. Examination of the data and scatter plots did not reveal any apparent relationship between hardwood pulpwood prices and quantities. Hence, no equations were estimated for this market.

3.3 The North

The North includes both the Northeast and North Central regions of the U.S. Supply models were estimated for sawtimber, but not for pulpwood. Northern pulpwood production was judged not to merit attention in this phase of the Pacific Rim Assessment project.

3.3.1 Softwood Sawtimber Supply

Northern softwood sawlog and veneer log production increased 33% between 1965 and 1987. Increased lumber production accounted for much of this growth. Log consumption for lumber totaled 9.1 mm m^3 in 1987. Veneer logs amounted to only 0.2 mm m^3 in 1987. Softwood log exports comprised 15% of the harvest in 1987, and also represented a significant source of growth over the historical period.

Data on sawtimber harvests are derived from estimates of lumber and plywood output, with appropriate accounting of trade volumes. For the price variable, we use the price of spruce stumpage in western Maine. Timber markets are quite competitive in western Maine, and since spruce lumber is produced in both the Northeast and Eastern Canada, this item seemed to be a particularly suitable price measure for an international trade model. Finally, examination of the USFS sales prices for the North (Region 9) indicated several anomalies that led us to prefer the Maine prices.

Figure 3.10 depicts the real sawtimber stumpage price in 1980 USD/m^3 and the cut-inventory ratio. The pattern is similar to other regions except for the extreme troughs that appear in 1974 and 1984. A scatter plot showing the relationship between these two variables is presented in *Figure 3.11*, and 1974 and 1984 show clearly as outliers. Estimation of the model with and without individual dummies for these two years resulted in nearly identical estimates of supply elasticities. The dummy variables had two effects: they increased substantially the explanatory power of the regression, and introduced serial correlation among the residuals. We did not include the dummies in the final equation (*Figure 3.12*). The elasticity of softwood sawtimber supply with respect to the stumpage price is 2.07, which is quite elastic relative to other regions in the U.S.

3.3.2 Hardwood Sawtimber Supply

The derivation and description of hardwood sawtimber harvests in the U.S. East are provided in Section 3.2.2.

Several different hardwood sawtimber stumpage price series were examined for the U.S. North, and rejected for a variety of reasons. We believe that the price series constructed for the Hardwood Assessment Market Model most accurately reflect prices in this region, and these data were used for the period 1960-1982. Because this series is very cumbersome to construct, it was updated using a volume-weighted average of Wisconsin maple and oak prices (a series which was shown to be very highly correlated with the data for the entire region).

Figure 3.13 depicts the real hardwood sawtimber stumpage price in 1980 USD/m^3 and the cut-inventory ratio. Whereas stumpage prices in other regions increase from 1960 to the late 1970s, this price is relatively flat until 1975, and then jumps sharply by 1979. Prices collapsed in the early 1980s, but have since rebounded.

A scatter plot depicting the stumpage price and the cut-inventory ratio is shown in *Figure 3.14*. A clear shift appears between 1978 and 1979. Several specifications of the supply model were tested. In the final equation (*Figure 3.15*), an intercept dummy was used for the 1979 to 1986 period. The model appears to fit the data well, and the elasticity of hardwood sawtimber supply with respect to the stumpage price is 0.74. The parameter estimates for an equation including real disposable income -- as used for hardwood sawtimber stumpage in the South -- suggest that supply is nearly perfectly elastic.

Figures 3.1-3.3: **U.S. South - Softwood Sawtimber**: Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 3.1 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

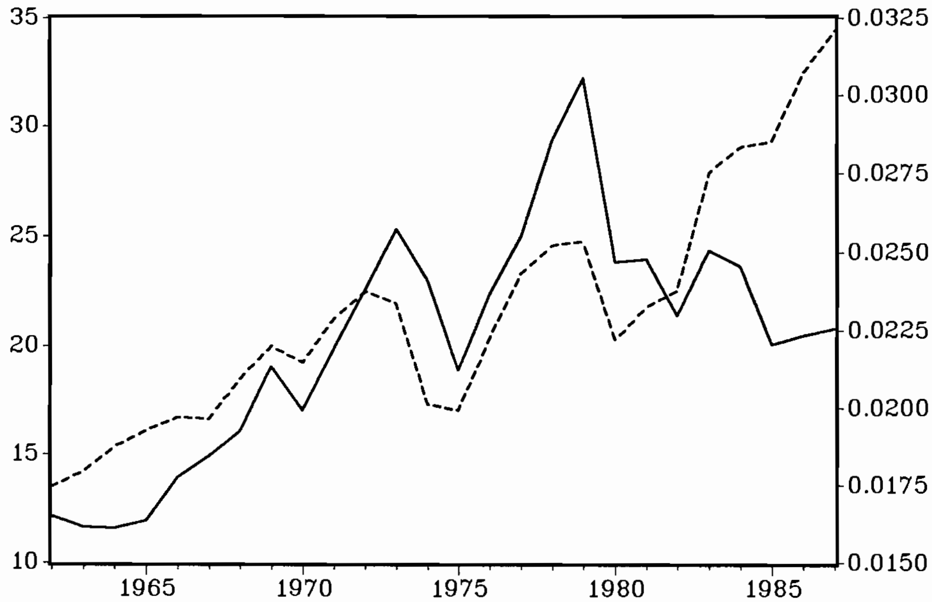


Figure 3.2 Scatter plot of **P** against **CI**

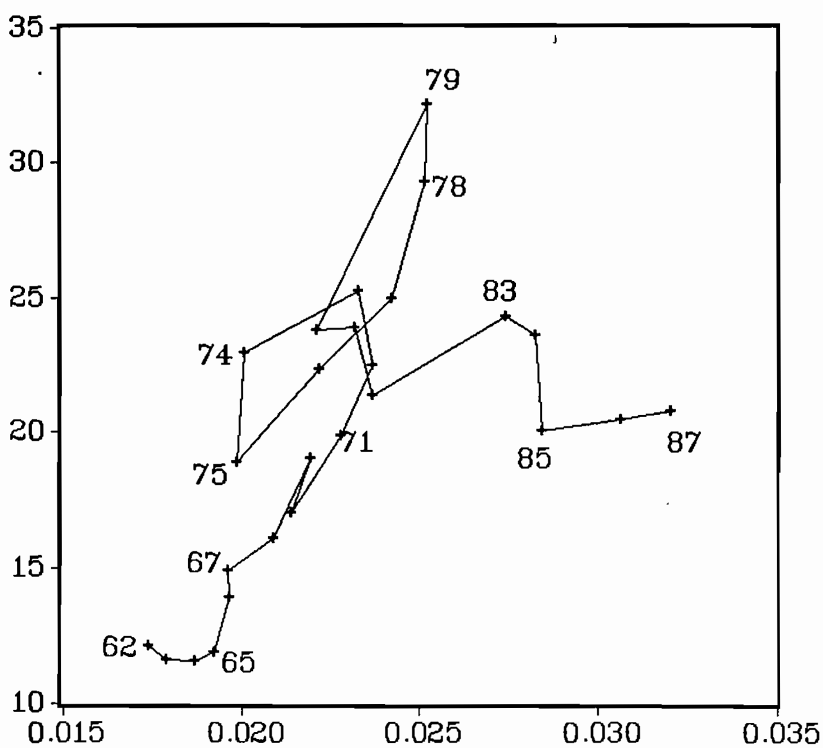


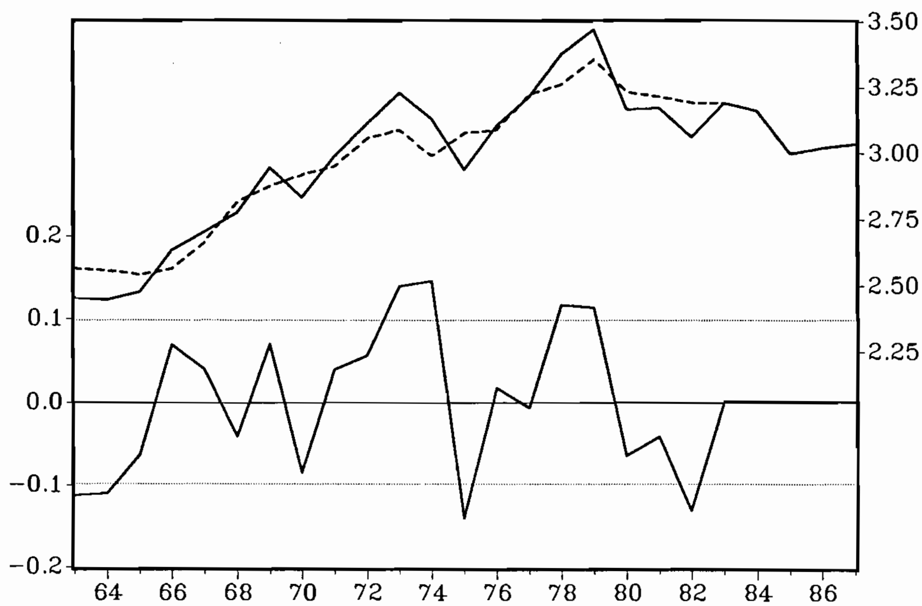
Figure 3.3 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1963 - 1987
Number of observations: 25
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	8.6659790	1.4860780	5.8314429	0.000
LN (CI)	1.4811903	0.3934285	3.7648275	0.002
D83	-0.0973997	0.1160956	-0.8389605	0.413
D84	-0.1794219	0.1516509	-1.1831243	0.253
D85	-0.3593341	0.1726832	-2.0808865	0.053
D86	-0.4545167	0.2001893	-2.2704346	0.036
D87	-0.5096261	0.2194252	-2.3225503	0.033
AR(1)	0.8396346	0.1268362	6.6198343	0.000

R-squared	0.909828	Mean of dependent var	2.986055
Adjusted R-squared	0.872699	S.D. of dependent var	0.275810
S.E. of regression	0.098407	Sum of squared resid	0.164627
Durbin-Watson stat	1.622180	F-statistic	24.50421
Log likelihood	27.31338		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 3.4-3.6: **U.S. South - Hardwood Sawtimber:** Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 3.4 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

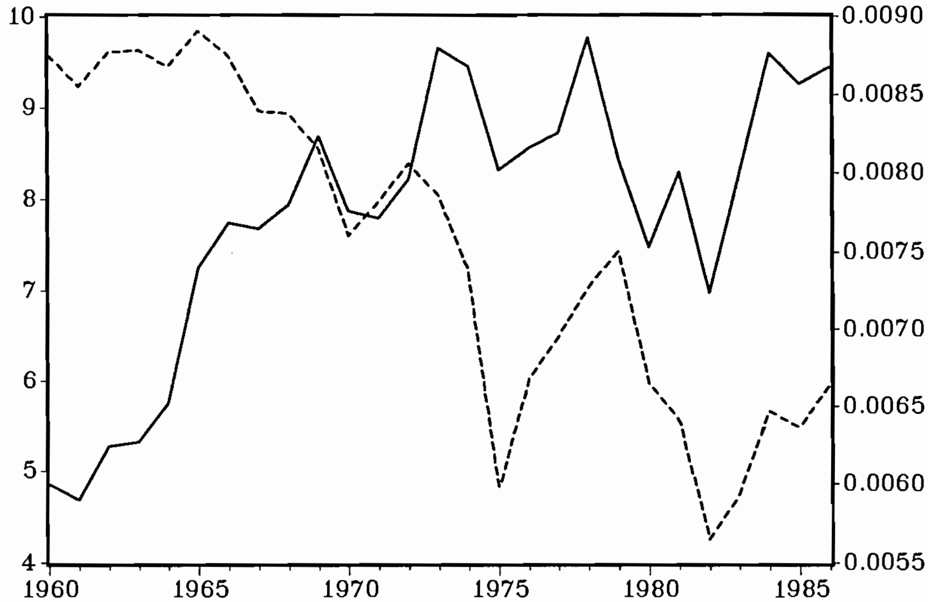


Figure 3.5 Scatter plot of **P** against **CI**

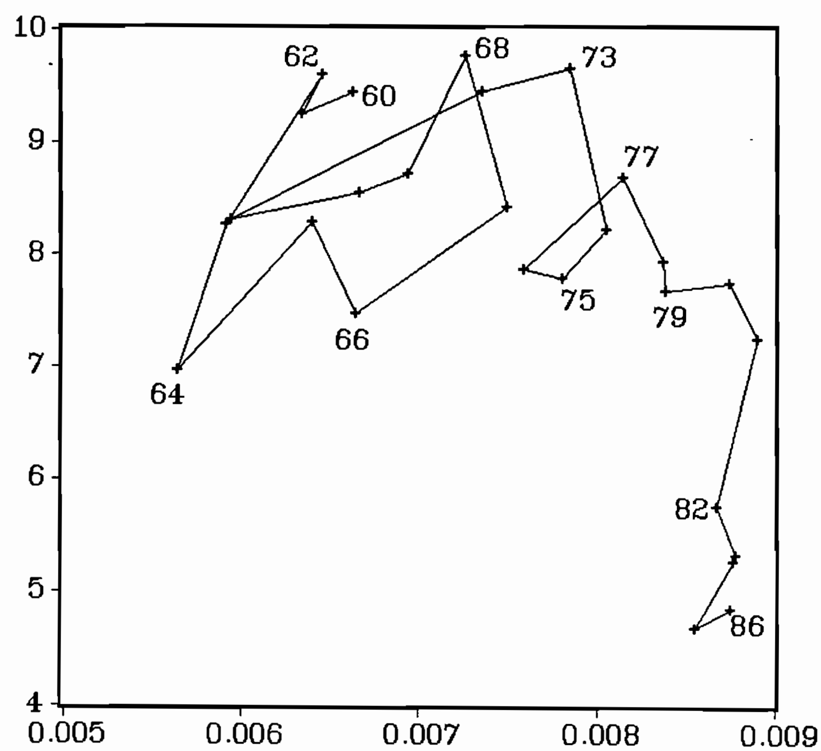


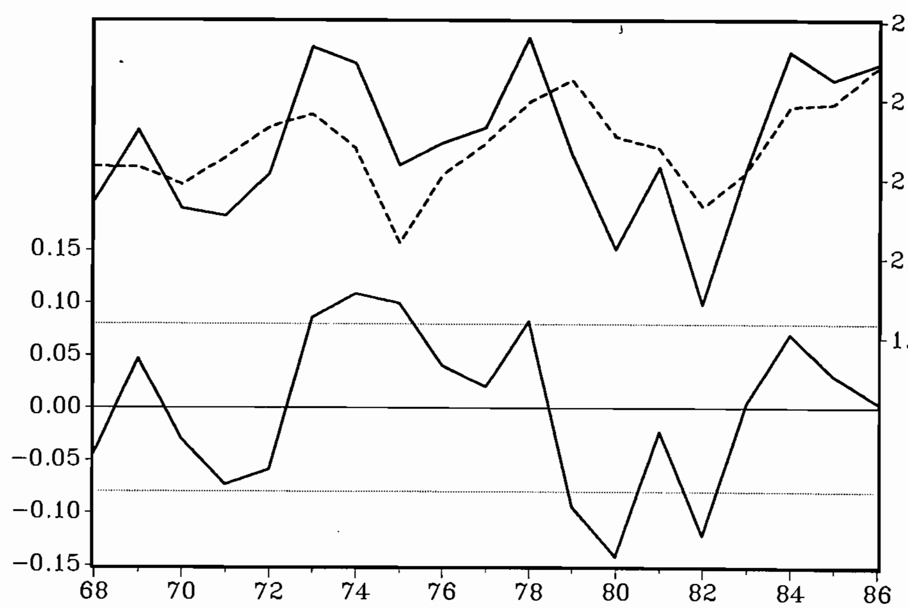
Figure 3.6 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1968 - 1986
Number of observations: 19

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1.3570429	0.9412388	1.4417626	0.169
LN (CI)	0.6060187	0.2340989	2.5887290	0.020
LN (DPY82)	0.4977507	0.1759494	2.8289428	0.012

R-squared	0.349788	Mean of dependent var	2.142922
Adjusted R-squared	0.268512	S.D. of dependent var	0.093638
S.E. of regression	0.080086	Sum of squared resid	0.102621
Durbin-Watson stat	1.232267	F-statistic	4.303685
Log likelihood	22.64114		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 3.7-3.9: **U.S. South - Softwood Roundwood Pulpwood:** Relationship between delivered price (**P**) in 1980 USD/clean green ton and cut in million m^3 (**Q**)

Figure 3.7 Historical trends in **P** and **Q**

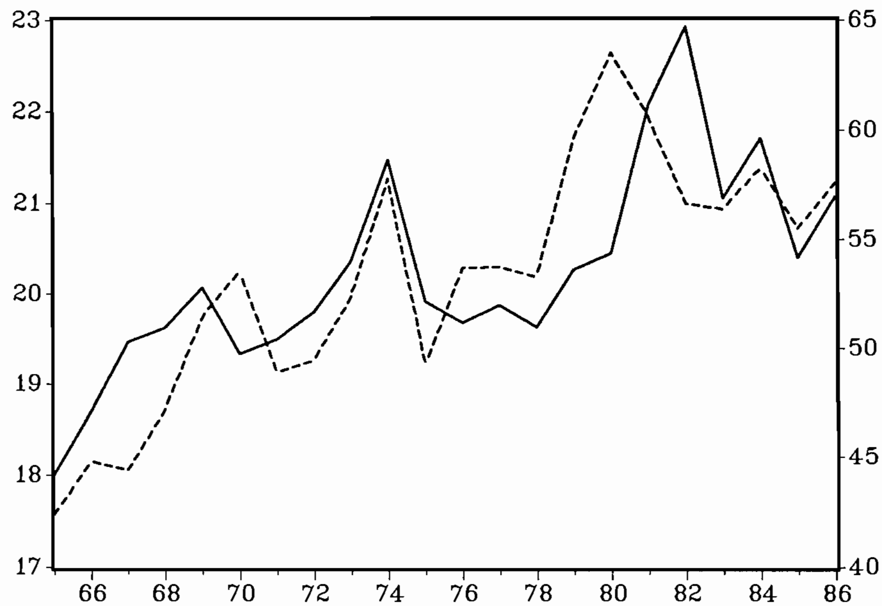


Figure 3.8 Scatter plot of **P** against **Q**

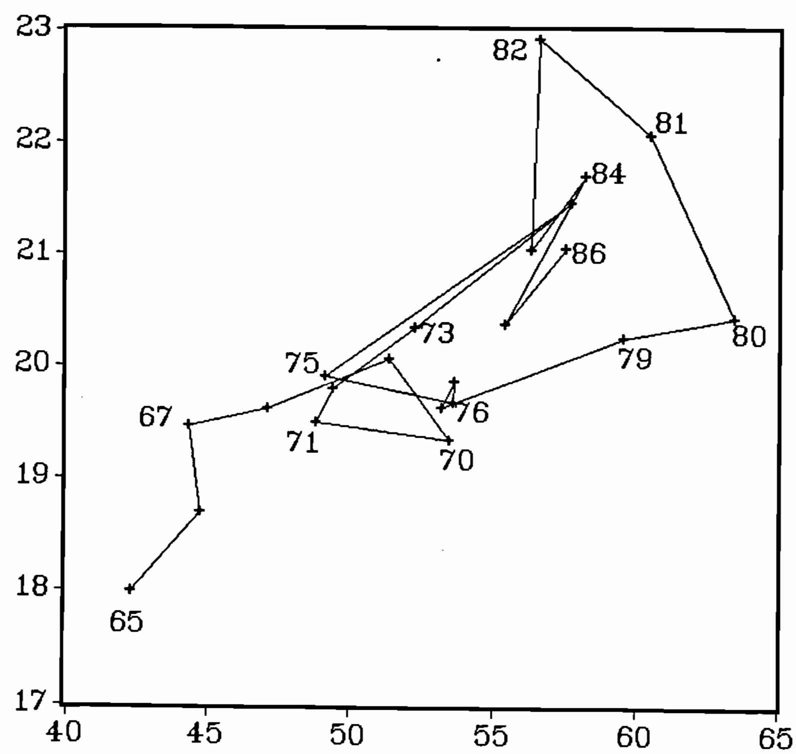


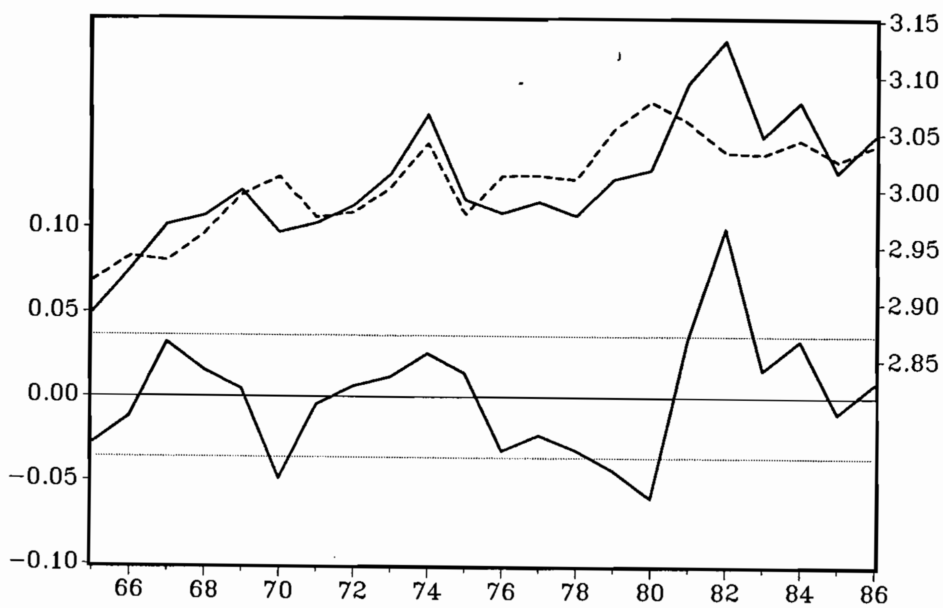
Figure 3.9 Regression results and plot of residual, actual, and fitted values

```
LS // Dependent Variable is LN (P)
SMPL range: 1965  -  1986
Number of observations: 22
```

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1.4441973	0.2948910	4.8973945	0.000
LN (Q)	0.3936162	0.0742898	5.2983915	0.000

R-squared	0.583966	Mean of dependent var	3.006103
Adjusted R-squared	0.563164	S.D. of dependent var	0.055112
S.E. of regression	0.036426	Sum of squared resid	0.026537
Durbin-Watson stat	1.257362	F-statistic	28.07295
Log likelihood	42.70628		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 3.10-3.12: **U.S. North - Softwood Sawtimber:** Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 3.10 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

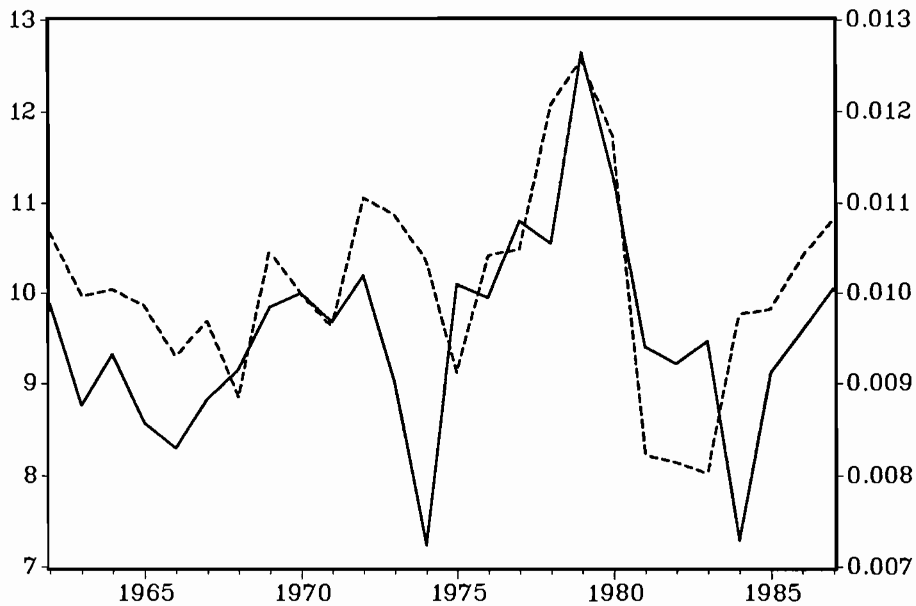


Figure 3.11 Scatter plot of **P** against **CI**

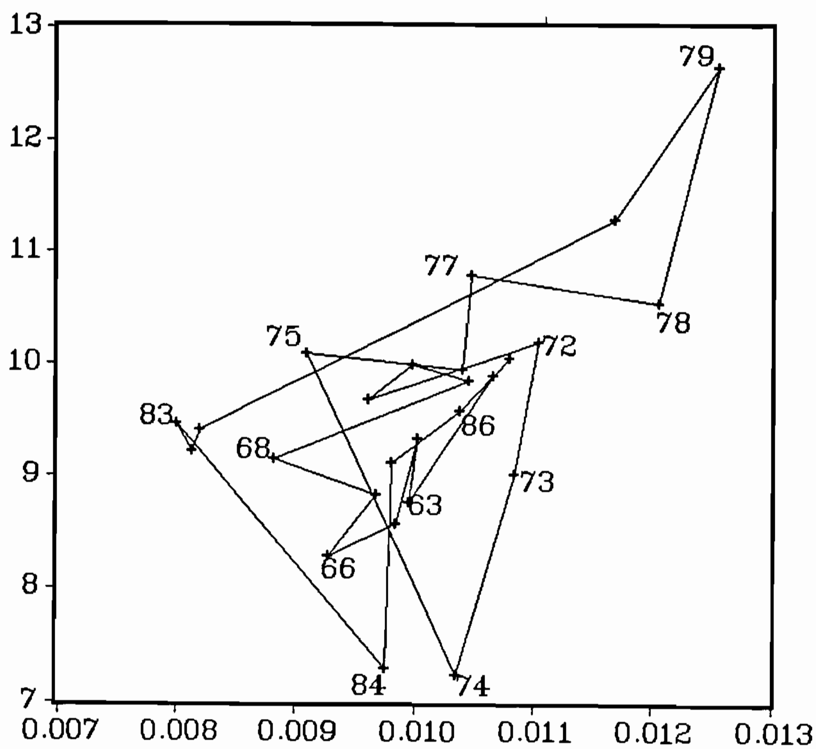


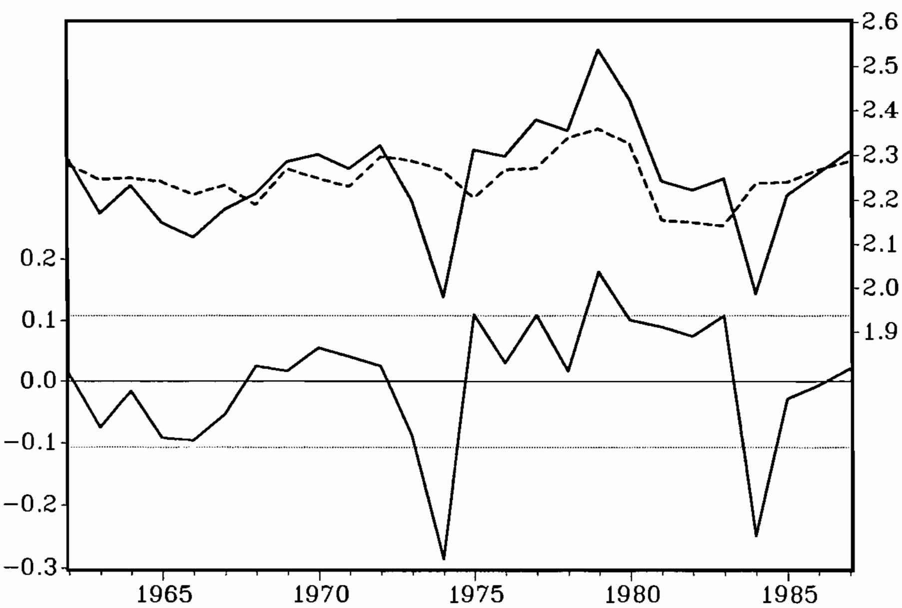
Figure 3.12 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1962 - 1987
Number of observations: 26

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	4.4771529	0.8881267	5.0411198	0.000
LN (CI)	0.4840407	0.1928969	2.5093238	0.019

R-squared	0.207835	Mean of dependent var	2.249185
Adjusted R-squared	0.174828	S.D. of dependent var	0.118506
S.E. of regression	0.107650	Sum of squared resid	0.278123
Durbin-Watson stat	1.680139	F-statistic	6.296706
Log likelihood	22.09886		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 3.13-3.15: **U.S. North - Hardwood Sawtimber**: Relationship between stumpage price (**P**) in 1980 USD/m^3 and cut-inventory ratio (**CI**)

Figure 3.13 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

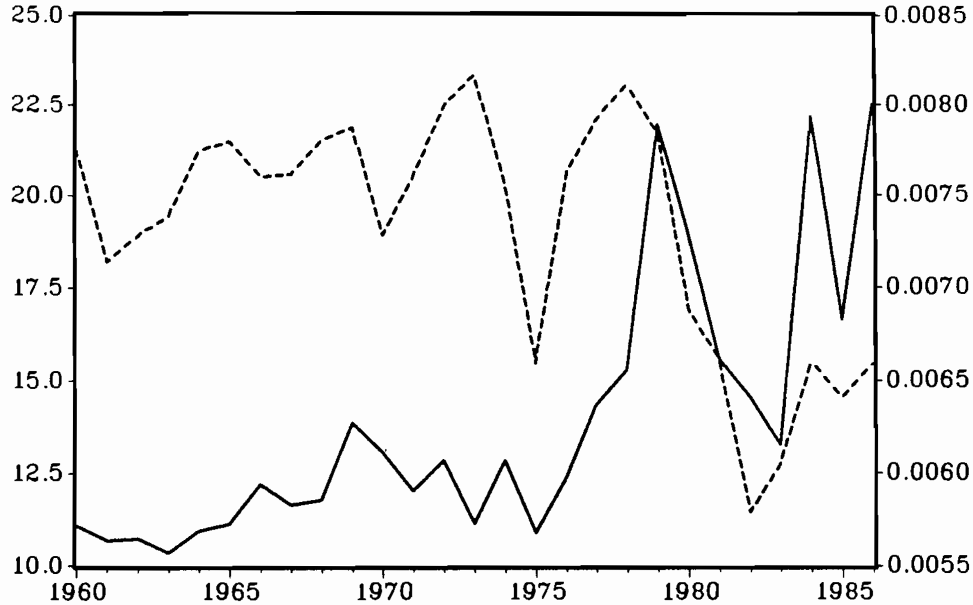


Figure 3.14 Scatter plot of **P** against **CI**

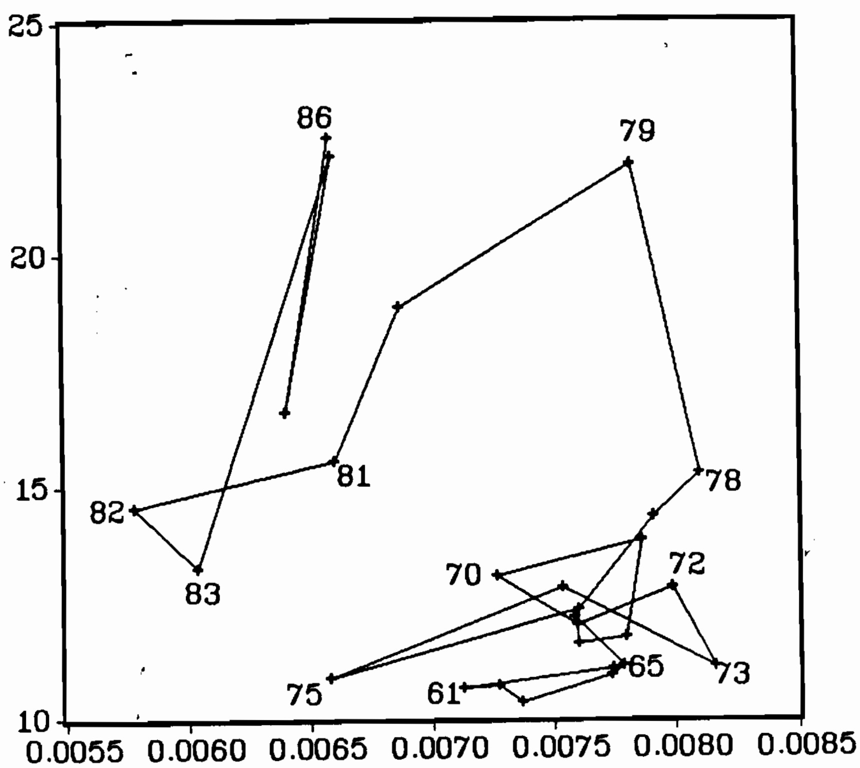


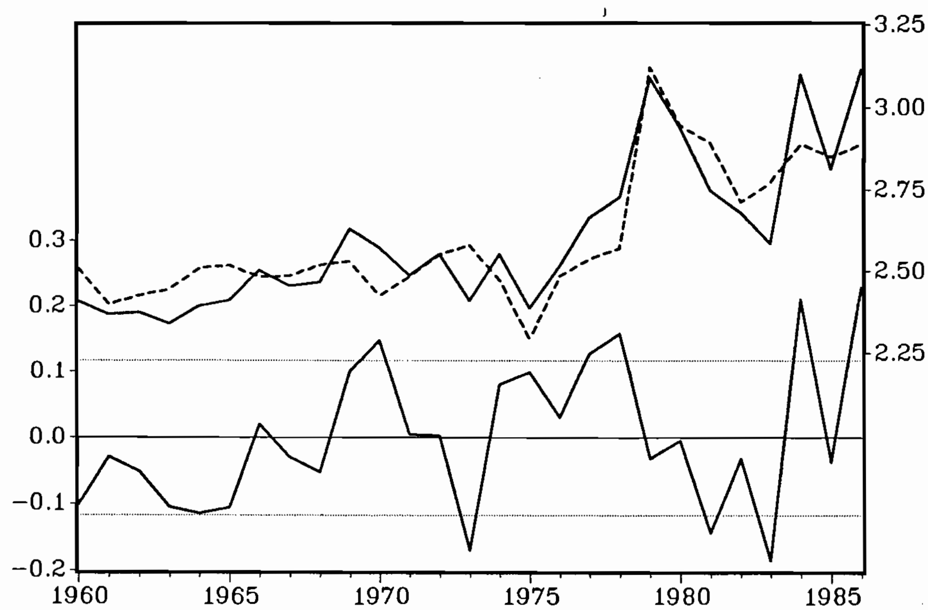
Figure 3.15 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1960 - 1986
Number of observations: 27

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	9.0785296	1.7756528	5.1127841	0.000
L (CI)	1.3520080	0.3639479	3.7148389	0.001
D7986	0.5974235	0.0726960	8.2181060	0.000

R-squared	0.768020	Mean of dependent var	2.601114
Adjusted R-squared	0.748688	S.D. of dependent var	0.232815
S.E. of regression	0.116712	Sum of squared resid	0.326922
Durbin-Watson stat	1.713611	F-statistic	39.72863
Log likelihood	21.27590		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



4. CANADA

4.1 Overview

For the purposes of the Pacific Rim Assessment, Canada is divided into three subregions, the B.C. Coast, Interior Canada (B.C. Interior, Alberta, Manitoba, and Saskatchewan), and Eastern Canada. Although there are some key differences among the regions in terms of species and product mix, there are several common features that tend to distinguish Canada from other regions.

The expansion of the forest products industry in Canada has proceeded rapidly since the early 1960s. The pattern of development provides a classic case of pushing back the extensive margin of timber supply, as higher prices in consuming markets have allowed producers to penetrate remote regions profitably. The extent of harvesting in the past decade has raised increasing concern about sustained yield and the longer-term viability of the industry. Canada's huge inventory of timber effectively been mined for many years, while regeneration practices have been poor and timber growth rates are very slow.

Canada possesses a very large forest land base, totaling 453.3 mm ha in 1986. The inventoried portion of that land base amounted to 397.9 mm ha: 243.7 mm ha belonged to the "productive" classification. The large majority of these forests are publicly-owned. The Provincial Crown owns 80% of the inventoried productive forest land, while the Federal Crown claims 11%.

Due to the extent of public ownership and widespread concern about "overcutting," increasing attention has been paid to the annual allowable cut (AAC). Though the government regulates the amount of timber that companies may harvest from a particular area, the constraints are relevant over multi-year periods. This provides companies with some management flexibility as they are allowed to deviate from these targets in the short-run. While the annual softwood harvest has increased over recent decades, the AAC has been revised downward. In 1970, the softwood AAC for Canada as a whole was 205 mm m^3, which was nearly twice the harvest. As of 1985, Canada's AAC was 166 mm m^3, which exceeded the national softwood harvest by only 11% (Reed, 1987). However, supplies were very tight in several provinces; only in Alberta, Manitoba, and Ontario did there appear to be significant opportunities for expansion. Our estimates suggest that 1987 softwood harvests in Canada substantially exceeded the AAC. Disparities continue at the provincial level however. We estimate that the cut in British Columbia far exceeds the AAC, whereas Alberta has room to continue its recent expansion.

Most of the growing stock in Canada is of harvestable size. Of the gross merchantable wood classified by "size," 73% (or 15.7 billion m^3) was classified as mature or overmature. The key short-run supply issue in Canada remains the rate at which to deplete the existing growing stock, rather than the actual physical availability of wood.

The volume of softwoods in Canada far exceeds the volume of hardwoods. In 1986, softwoods comprised 77% of the gross merchantable wood in Canada (the softwood volume was 17.8 billion m^3). The variation across provinces is substantial. The inventory in British Columbia is 92% softwoods. This compares with 63% in Alberta, 62% in Ontario, 71% in Quebec, and 74% in the Maritime provinces. Of the total volume of softwoods in Canada, 79% are classified as spruce-pine-fir, and approximately half of that is spruce. In some provinces, softwoods are comprised of almost entirely spruce-pine-fir: the shares in Alberta, Ontario, and Quebec are 99%, 95%, and 96%, respectively. However, in British Columbia, spruce-pine-fir constitutes only 67% of the softwood growing stock, due to the importance of hemlock (15%), cedar, and Douglas-fir. For hardwood species, 56% of the volume in Canada is classified as aspen or poplar, 21% is birch, and 12% is maple.

Product and species mixes vary substantially across the Canadian regions. Generally, the B.C. Coast and Interior Canada are softwood sawlog producers. Although the pulp industry is sizable, it relies primarily on sawmills for its fiber furnish. Hardwood production tends to be extremely small. Eastern Canada shows a very different orientation. Roundwood pulpwood production is substantial and exceeded sawlog production in 1985. Hardwood production is significant, but is still dwarfed by softwoods.

Sawtimber supply models in Canada differ from those in the U.S. in two important ways. First, delivered sawlog prices are modeled directly -- stumpage prices and harvest and delivery costs are not recognized individually. It is difficult to obtain data on stumpage prices in Canada, but, more importantly, they represent a very small proportion of sawlog prices. Second, the inventory term is omitted from the Canadian supply models. Because of the method of establishing the AAC in Canada, we do not believe that the rationale for the inventory term is applicable. It is certainly true that inventory will govern production in the very long run. However, for our modeling objectives, it is best to attempt to incorporate changes in the AAC explicitly.

One final note is in order concerning stumpage price determination. Due to U.S. complaints and legal action concerning the possible subsidization of timber production in Canada, stumpage price formulas are currently undergoing major changes. This means that stumpage charges may rise substantially. Due to the lack of current log price data, and lack of reliable information on how these changes are being implemented in different regions, we have not incorporated these revisions in the current version of the Pacific Rim Assessment model. However, these adjustments will need to be addressed in the future.

The majority of data used in the analysis of Canadian regions is taken from various Statistics Canada publications. In some cases, there are long delays between the period of interest and the publication date. As a result, some of the recent data had to be estimated.

4.2 The B.C. Coast

The B.C. Coast is separated from the B.C. Interior because of its importance as a producer of forest products, and because of differences in the economics of production and distribution. Because of its good ports and access to ocean transportation, the B.C. Coast exports a significant volume of lumber and sawlogs.

We have not analyzed the hardwood sector in the B.C. Coast. In 1983, hardwood sawlog production was reported to be 0.22 mm m^3 and hardwood roundwood pulpwood production was combined with softwoods. Since 1983, hardwood sawlog production also has been aggregated with softwoods.

4.2.1 Softwood Sawtimber Supply

Because of its favorable geographical position, the forest product industry in the B.C. Coast developed earlier than other Canadian regions. The harvest of softwood sawlogs and veneer logs increased only gradually from 1960 to the early 1970s. Though log production has subsequently been highly cyclical, it appears to have reached a plateau about that time. The vast majority of sawlog/veneer logs are consumed in lumber manufacturing, with plywood and log exports consuming relatively minor shares. Log exports from the province are not permitted unless they are surplus to domestic needs. In recent years however, log exports have climbed considerably. We estimate that log production for lumber was 19.9 mm m^3 in 1987, and log exports reached 3.7 mm m^3.

Data on sawtimber harvests are derived from estimates of lumber production and log trade. Plywood production is ignored because it accounts for a small share of the harvest, and because we do not model timber inventory in this region. The price variable is derived from the total quantity and value of roundwood purchased by major establishments in the region. The 1960-1984 data are from Statistics Canada Publication 35-204, "Sawmills and Planing Mills and Shingle Mills"; the 1985 data are from 35-250, "Wood Industries"; and, the 1986 and 1987 data are estimated.

Figure 4.1 depicts the real delivered sawlog price in 1980 CND/m^3 along with the harvest level. Real sawlog prices climbed steadily from 1961 to the late 1970s and surged in 1979. As in other regions of North America, sawlog prices fell significantly in the 1980s. The harvest level also grew throughout the 1960s, but there are some years during this period when price and quantity movements appear countercyclical. The harvest level dropped precipitously in 1975, and again in 1980-1981. Harvest returned to historical highs in 1987, but there is no indication that prices kept pace.

An examination of the scatter plot (*Figure 4.2*) showing the relationship between the real delivered sawlog price and the harvest level led us to eliminate the period 1960 to 1971 as irrelevant to current markets and future trends. To account for the apparent structural shift after 1983, we use two dummy variables. The final equation is shown in

Figure 4.3. The elasticity of softwood sawtimber supply with respect to the delivered price is 3.2.

4.2.2 Softwood Pulpwood Supply

As with pulpwood supply models in the U.S., roundwood pulpwood supply is estimated as a function of the real price of wood chips. There are no direct estimates of roundwood pulpwood production in the B.C. Coast, apparently for reasons concerning disclosure. However, estimates of total softwood roundwood production are available (Statistics Canada Bulletin 25-201, "Logging Industry," Table 7). We derive roundwood pulpwood production by subtracting sawlog harvest (calculated as described in 4.2.1) from the total harvest. The real price of softwood wood chips is calculated based on the total value and volume of wood chips from softwood sawmill and planing mills in the B.C. Coast (the sources are the same as those used to derive sawlog prices).

Figure 4.4 depicts the real softwood chip price in 1980 CND/m^3 and the production of softwood roundwood pulpwood. Both trends are highly cyclical, and prices and harvests are quite low in recent years. The scatter plot in *Figure 4.5* suggests the appropriate relationship between the two variables, but there are several troublesome outliers. The final equation, shown in *Figure 4.6*, indicates that the elasticity of roundwood pulpwood supply with respect to the delivered price is 1.9. However, our understanding of this market is quite limited and this analysis could be expanded significantly.

4.3 Interior Canada

The lion's share of softwood sawlog production in the region designated Interior Canada occurs in Interior B.C. In 1987, Interior B.C. produced 86% of the softwood lumber in this region. Alberta, a small, but significant producer, accounted for 12% of lumber production. The remaining 2% is produced in Manitoba and Saskatchewan.

Softwood roundwood pulpwood production in Interior Canada is small relative to softwood sawlog production. As with the B.C. Coast, the data must be inferred on the basis of total harvests and sawlog harvest (which, in turn, is derived from product output). Due to the relatively small volume, the high likelihood of measurement errors, and the poor estimation results in the exploratory analysis, we decided that pulpwood prices in this region should be projected exogenously.

Hardwood production in the Interior Canada region is too small to warrant attention. Hardwood sawlog production in 1985 was only 0.74 mm m^3 (nearly 80% in Alberta), while hardwood roundwood pulpwood production was only 0.65 mm m^3 (with roughly equivalent production levels in the Alberta and Saskatchewan). As with the B.C. Coast, the B.C. Interior data are available for hardwood sawlogs until only 1983: production in that year totaled 0.06 mm m^3. We do not have an estimate of hardwood roundwood pulpwood production in the B.C. Interior.

Softwood Sawtimber Supply

Softwood sawlog production is derived from estimates of softwood lumber production. (Plywood production is relatively small in this region.) The harvest of softwood sawlogs has increased dramatically since 1960, and the rate of increase has accelerated in recent years. The price variable reflects the average real price of softwood roundwood purchased by sawmills in the B.C. Interior and Alberta, and it is derived from the same sources as the B.C. Coast data. After surges in 1973 and 1979, real prices have remained at low levels in the 1980s. Real prices and harvest levels are shown in *Figure 4.7*.

Figure 4.8 presents a scatter plot of real prices against harvest levels. Our interpretation of this diagram is that we observe something like a classical supply relationship between 1967 and 1975. A major outward shift in this supply relationship occurred in 1976, possibly reflecting a lagged response to high profit levels in 1973 and 1974. Since 1982, the curve has continued to shift outward, though somewhat erratically. After several attempts at alternative specifications, we accepted the equation shown in *Figure 4.9*. The estimation period was restricted to 1971-1987. We used the data from 1971-1975 and 1976-1982 to provide information on the elasticity of sawtimber supply. Based on this equation, the elasticity is 1.1, which is substantially less elastic than in the B.C. Coast.

4.4 Eastern Canada

Eastern Canada consists of Ontario, Quebec, and the Maritime provinces. The region currently ranks between the B.C. Coast and Interior Canada in terms of the volume of softwood sawlogs produced. However, it is substantially larger than the other regions in the production of softwood roundwood pulpwood, hardwood sawlogs, and hardwood pulpwood. Estimated production levels in 1985 were: softwood sawlogs, 29.4 mm m^3; softwood roundwood pulpwood, 32.8 mm m^3; hardwood sawlogs, 4.1 mm m^3; and, hardwood pulpwood, 3.6 mm m^3. Production levels in Ontario and Quebec dwarf those in the Maritimes.

For a variety of reasons concerning data availability, and modeling objectives, we have estimated only a softwood sawlog equation for this region.

Softwood Sawtimber Supply

Softwood sawlog production is derived from estimates of softwood lumber production. As with Interior Canada, the harvest of softwood sawlogs has increased dramatically since 1960; however, the pattern of expansion differs significantly. Production increases in this region were more modest from 1960 to 1974, and the production surge from 1975 to 1980 was much more rapid. The price variable reflects the average real price of softwood roundwood purchased by sawmills in Ontario and Quebec (see Section 4.2.1 for data sources). Unlike other regions in North America, this price series shows remarkable stability over the last 25 years. *Figure 4.10* presents the real price and harvest data.

A scatter plot depicting the relationship between real delivered sawlog prices and harvest levels is shown in *Figure 4.11*. We clearly observe the continued expansion of this industry at relatively stable prices. Three hypotheses as to why this expansion occurred are: 1) rather than incurring longer hauling costs at extant sawmills, sawmills may have been constructed in more remote regions; hence, log delivery costs could have remained stable while product delivery costs rose; 2) government methods of pricing stumpage may have insured that the industry remained profitable; and, 3) lumber industry expansion may have been a byproduct of growth in the pulp and paper industry in this region. It is not possible to test these hypotheses using our simple specification of timber supply. Rather than develop a richer theory of timber exploitation for this region, we believe that we can use recent observations to develop some estimates of short-run supply behavior. This appears feasible since the majority of the development of this region has probably already occurred.

The final equation is presented in *Figure 4.12*. The elasticity of softwood sawlog supply with respect to the delivered price is 1.4. Although the fit is reasonable, the estimated parameter is based on a very small sample.

Figures 4.1-4.3: **B.C. Coast - Softwood Sawtimber**: Relationship between delivered price (**P**) in 1980 CND/m^3 and cut in million m^3 (**Q**)

Figure 4.1 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

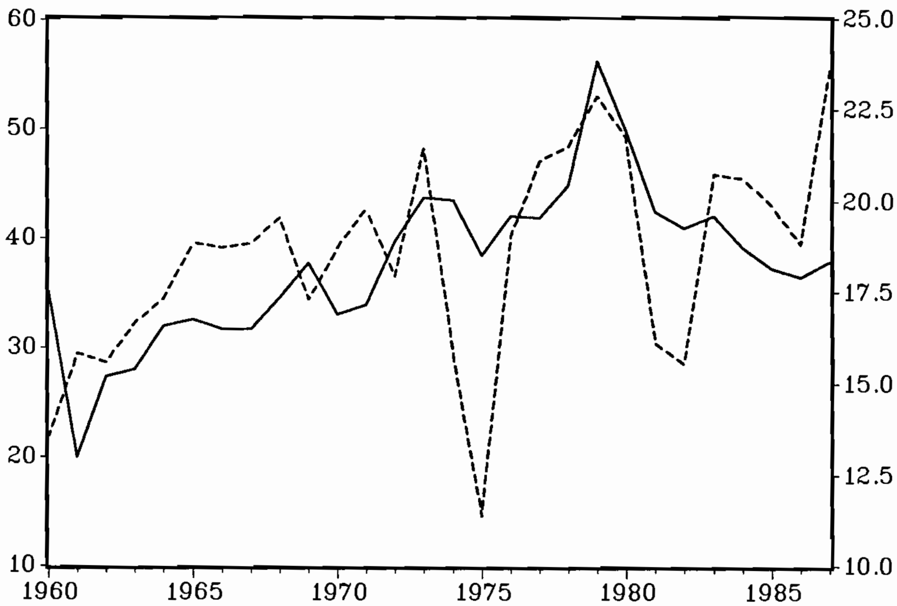


Figure 4.2 Scatter plot of **P** against **Q**

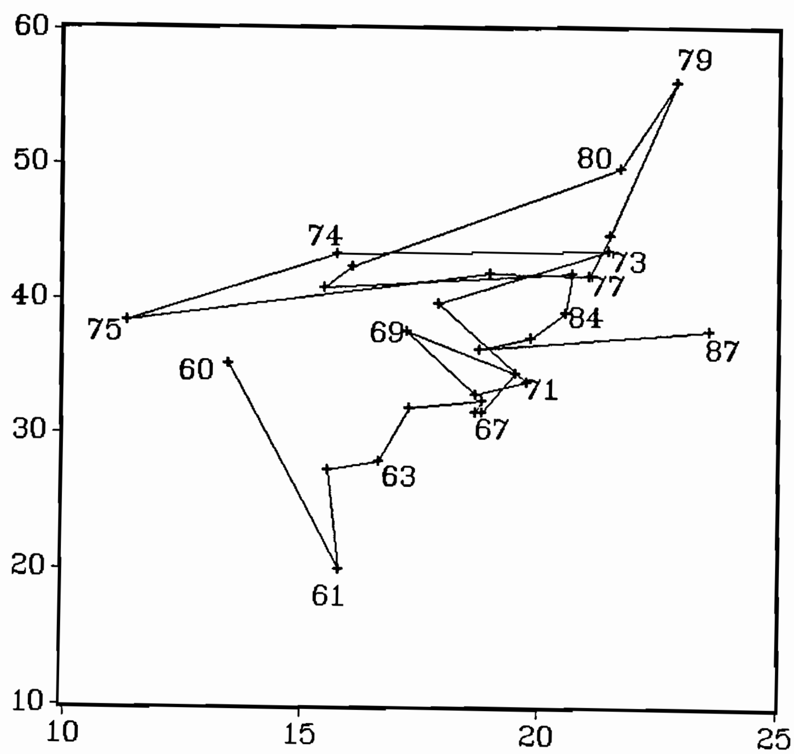


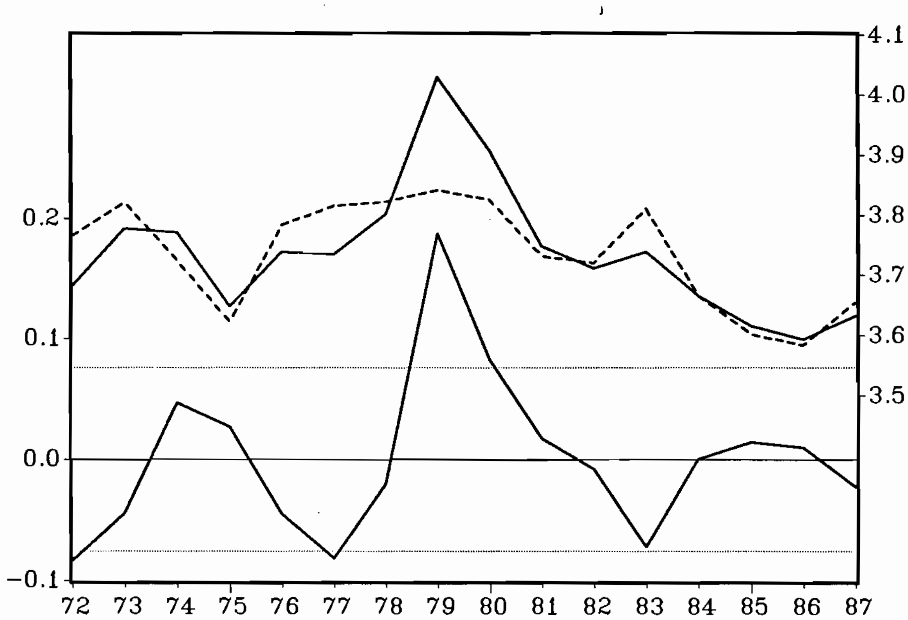
Figure 4.3 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1972 - 1987
Number of observations: 16

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.8564697	0.3166839	9.0199402	0.000
LN (Q)	0.3145900	0.1084225	2.9015202	0.013
D84	-0.1433997	0.0799157	-1.7943863	0.098
D8587	-0.1964000	0.0505352	-3.8864020	0.002

R-squared	0.625968	Mean of dependent var	3.736295
Adjusted R-squared	0.532459	S.D. of dependent var	0.110990
S.E. of regression	0.075892	Sum of squared resid	0.069115
Durbin-Watson stat	1.303142	F-statistic	6.694261
Log likelihood	20.85357		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 4.4-4.6: **B.C. Coast - Softwood Roundwood Pulpwood:** Relationship between delivered price (**P**) in 1980 CND/m^3 and cut in million m^3 (**Q**)

Figure 4.4 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

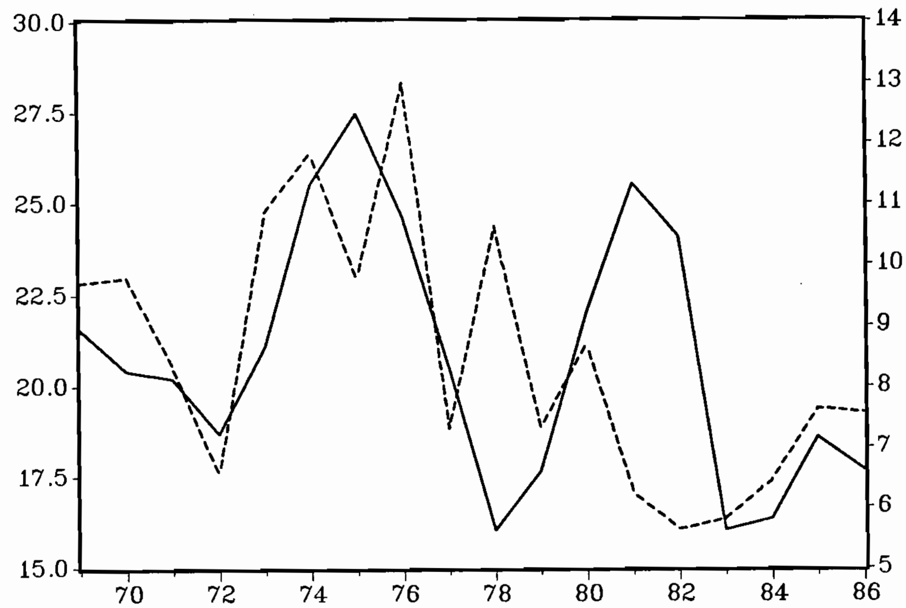


Figure 4.5 Scatter plot of **P** against **Q**

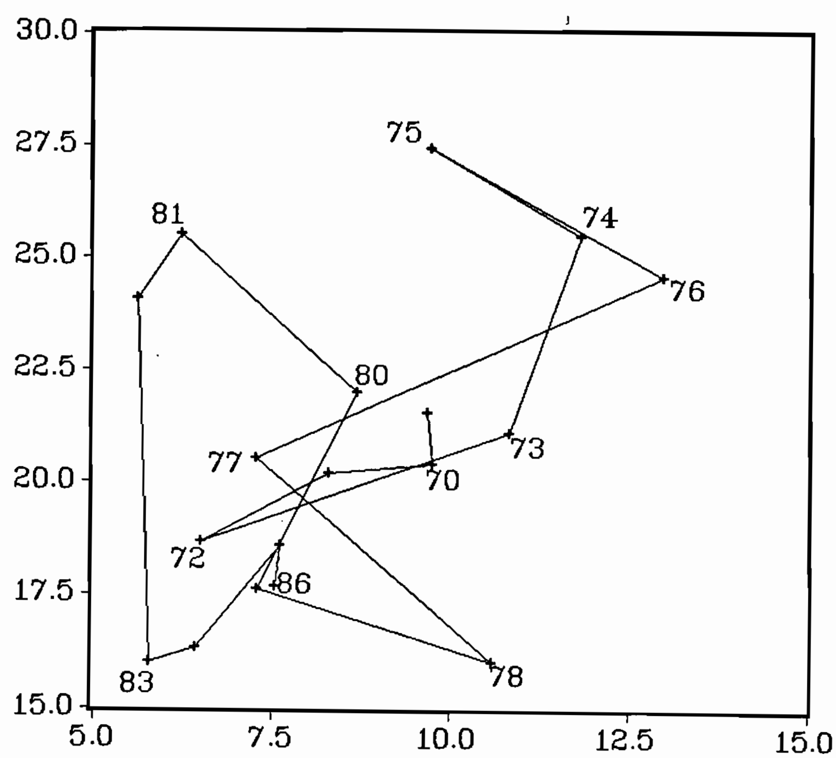


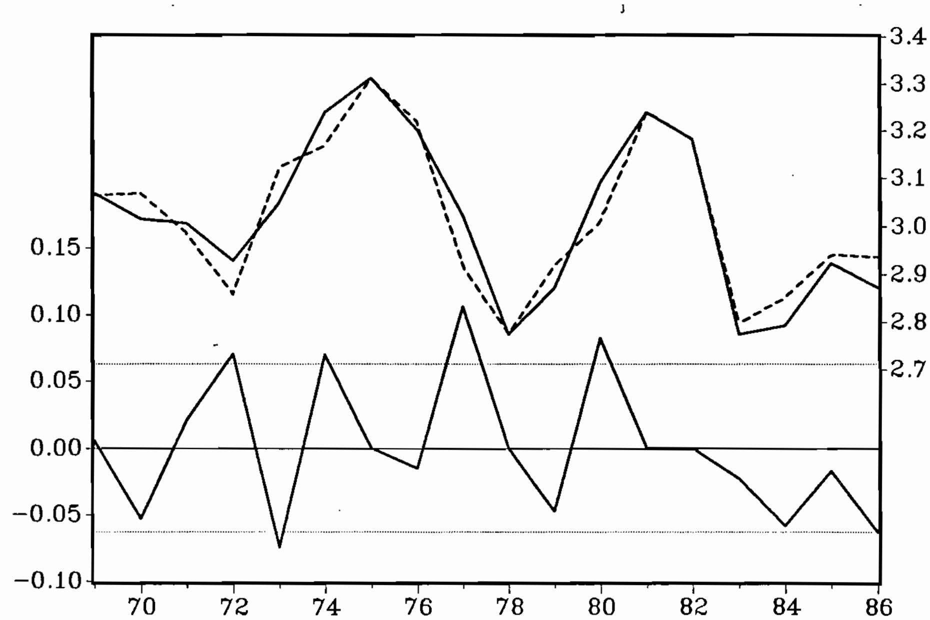
Figure 4.6 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1969 - 1986
Number of observations: 18

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	1.8801902	0.1551854	12.115769	0.000
LN (Q)	0.5215636	0.0725430	7.1897194	0.000
D75	0.2456110	0.0659621	3.7235174	0.003
D78	-0.3383538	0.0672811	-5.0289591	0.000
D81	0.4062054	0.0686020	5.9211859	0.000
D82	0.4008198	0.0712816	5.6230506	0.000

R-squared	0.902224	Mean of dependent var	3.019883
Adjusted R-squared	0.861484	S.D. of dependent var	0.168932
S.E. of regression	0.062873	Sum of squared resid	0.047436
Durbin-Watson stat	2.441682	F-statistic	22.14597
Log likelihood	27.90791		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 4.7-4.9: **Interior Canada - Softwood Sawtimber:** Relationship between delivered price (**P**) in 1980 CND/m^3 and cut in million m^3 (**Q**)

Figure 4.7 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

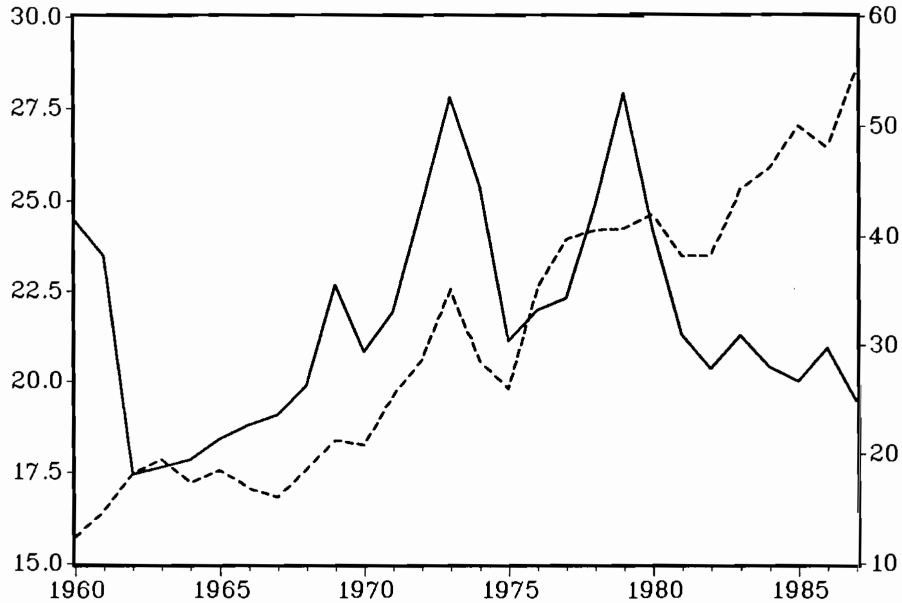


Figure 4.8 Scatter plot of **P** against **Q**

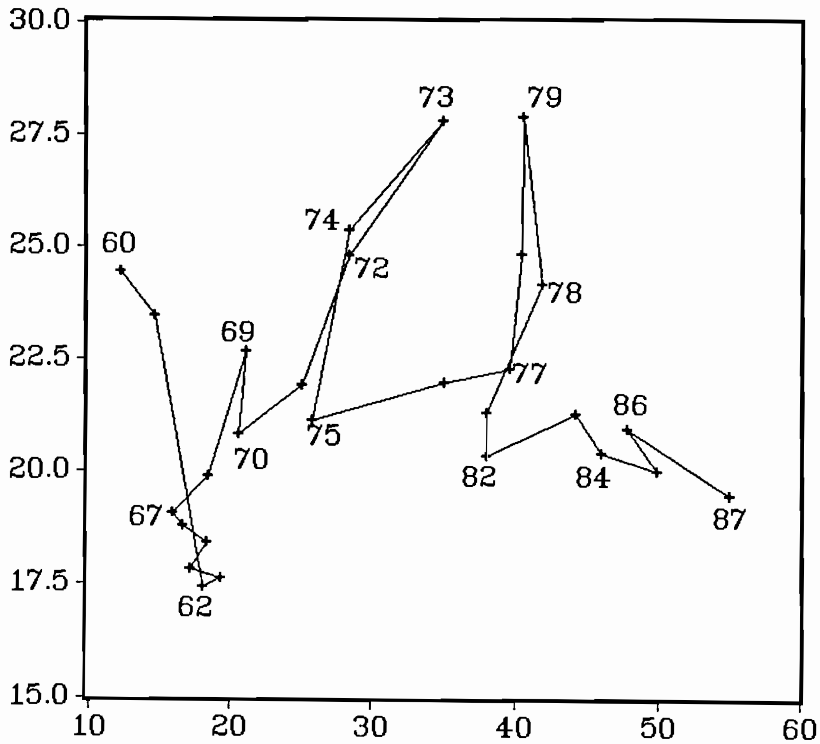


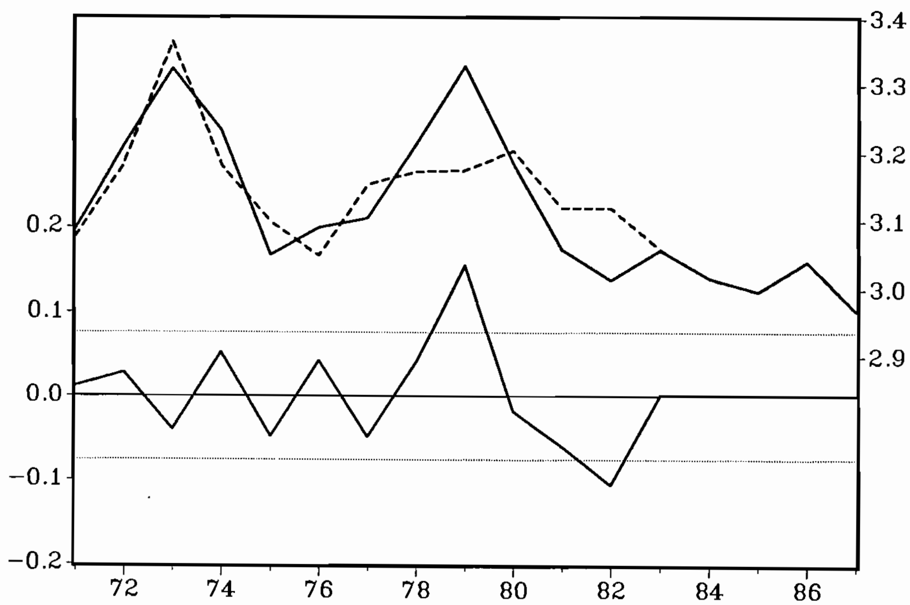
Figure 4.9 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1971 - 1987
Number of observations: 17

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.2411258	0.8629227	0.2794293	0.786
LN (Q)	0.8781210	0.2575124	3.4100141	0.008
D7682	-0.3204473	0.0936048	-3.4234053	0.008
D83	-0.5132201	0.1413849	-3.6299502	0.005
D84	-0.5915084	0.1501296	-3.9399858	0.003
D85	-0.6808184	0.1674766	-4.0651558	0.003
D86	-0.5992949	0.1582298	-3.7874969	0.004
D87	-0.7940984	0.1896052	-4.1881682	0.002

R-squared	0.740536	Mean of dependent var	3.116078
Adjusted R-squared	0.538731	S.D. of dependent var	0.112299
S.E. of regression	0.076270	Sum of squared resid	0.052353
Durbin-Watson stat	2.019432	F-statistic	3.669555
Log likelihood	25.03313		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 4.10-4.12: **Eastern Canada - Softwood Sawtimber:** Relationship between delivered price (**P**) in 1980 CND/m^3 and cut in million m^3 (**Q**)

Figure 4.10 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

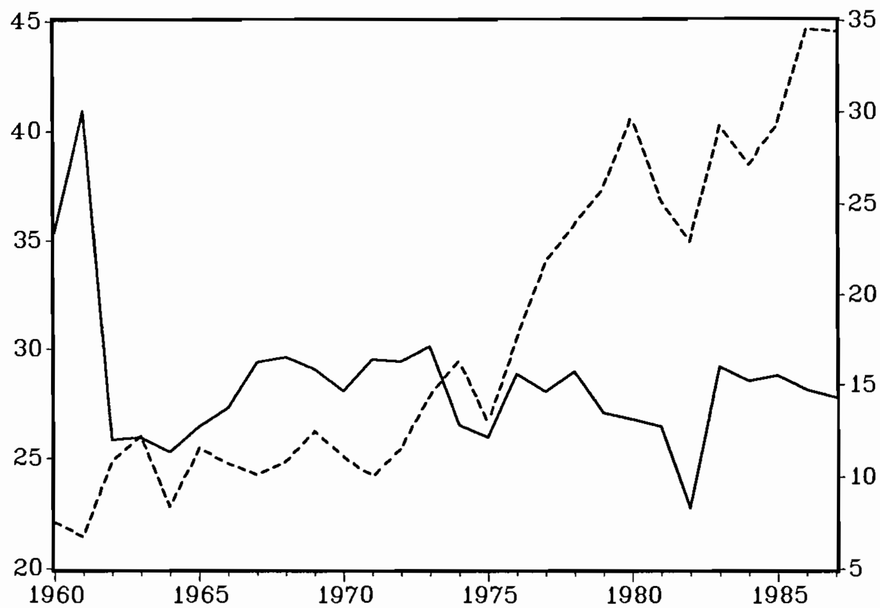


Figure 4.11 Scatter plot of **P** against **Q**

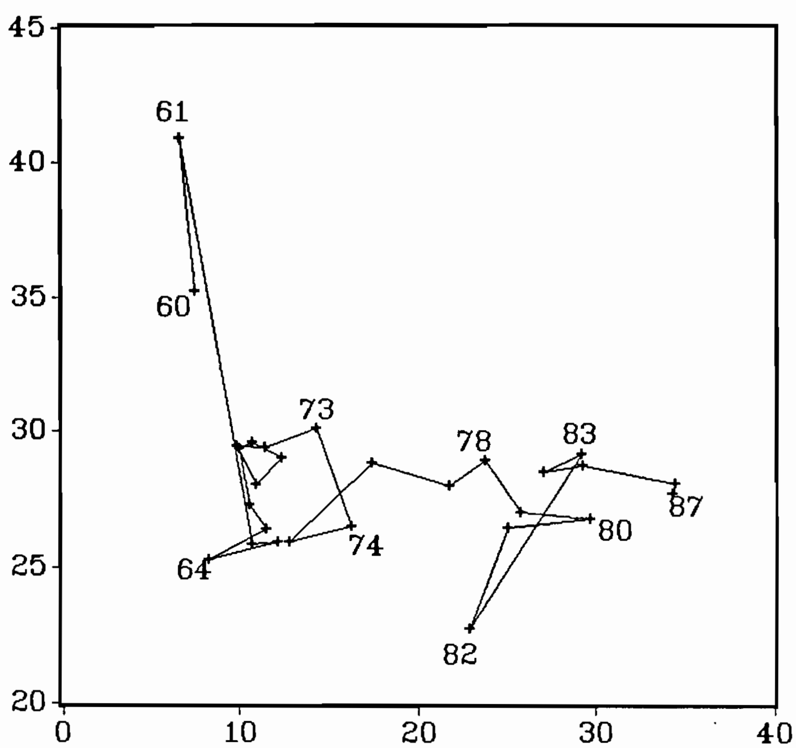


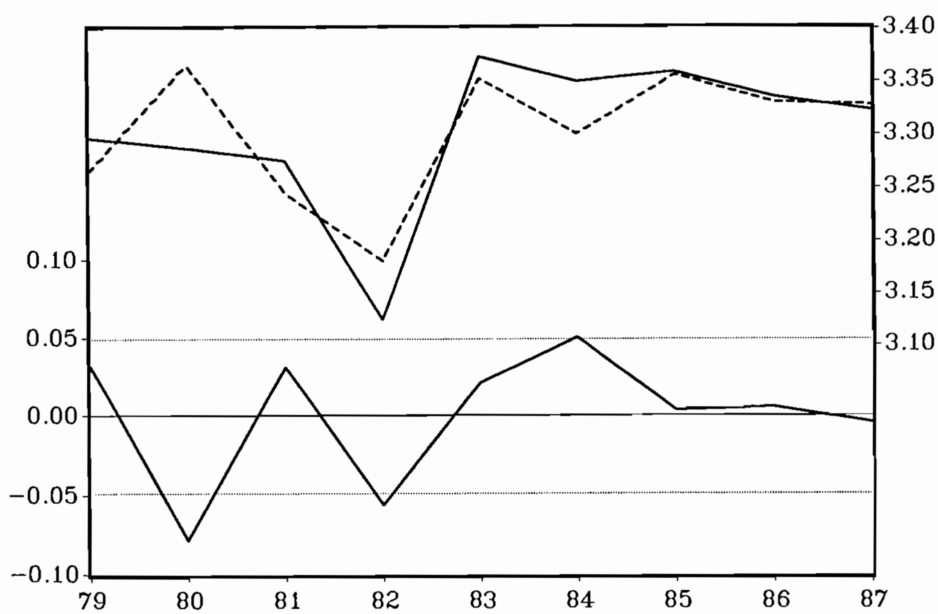
Figure 4.12 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1979 - 1987
Number of observations: 9

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.9606740	0.6735702	1.4262418	0.204
LN (Q)	0.7084360	0.2043826	3.4662247	0.013
D8687	-0.1393987	0.0635693	-2.1928634	0.071

R-squared	0.680288	Mean of dependent var	3.302099
Adjusted R-squared	0.573717	S.D. of dependent var	0.074919
S.E. of regression	0.048915	Sum of squared resid	0.014356
Durbin-Watson stat	2.855684	F-statistic	6.383445
Log likelihood	16.21325		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



5. WESTERN EUROPE

5.1 Overview

Western Europe is important to the Pacific Rim Assessment because of direct interactions with the Pacific Northwest, and because of "third-party" trade between regions that participate in the Pacific Rim market. For example, Chile has the potential to export a large volume of wood to the Pacific Rim market in the future, but Chile is also well positioned to ship this timber to European consumers.

In the Pacific Rim Assessment analysis, Western Europe is subdivided into three regions: Finland, Sweden, and Other Western Europe. Finland and Sweden are presented separately due to the high quality of their data and their importance in world trade. For example, according to FAO statistics for 1985, the two countries accounted for 17% of world coniferous sawnwood exports, 24% of world pulpwood imports, and 21% of world pulp exports. Other Western Europe is difficult to model as an aggregate due to the heterogeneous characteristics of the timber market in member countries and the differences in currencies. For this reason, we retain Other Western Europe as an endogenous region, but parameter estimates are established judgmentally based on related analyses.

In terms of silvicultural practices, Finland and Sweden certainly rank among the most advanced countries in the world. Their long history of forest management has probably been responsible for the achievement of this status. Thus, in spite of relatively adverse climatic conditions, they have attained a significant place in world forest products markets.

Recent forest surveys suggest that the inventory in these two countries is expanding quite rapidly. Using these data, we estimate that the softwood inventory in Finland has grown over 25% between 1965 and 1987, and now totals 1.48 billion m^3. Finnish hardwoods have also grown rapidly, rising 30% from 1973 to 1987, and now registering 0.35 billion m^3. The Swedish softwood inventory reached 2.20 billion m^3 in 1987, showing 12% growth since 1965. Hardwoods grew 17% from 1965 to 1987, and now total 0.40 billion m^3.

Species diversity in Finland and Sweden is quite limited: spruce, pine, and birch comprise the vast majority of the growing stock in both countries. In Finland, forest survey data indicate that in (approximately) 1980, pine accounted for 62% of the inventory, spruce comprised 27%, and birch accounted for 7%. Sweden, in 1984, contained almost the same share of softwood, but a much larger percentage of spruce: species shares were pine 38%, spruce 45%, and birch 11%.

Nonindustrial private ownership is an important dimension of timber supply behavior in the Nordic region. Nonindustrial private owners claimed 63% of the forest land in Finland in recent years. In Sweden, this same group owned 50% of the land. Due to supply issues and forest management questions associated with this owner group, supply behavior in these regions shows parallels with the U.S. South.

The solid wood products industry in Finland and Sweden is almost exclusively sawnwood. The veneer and plywood industry is extremely small, and consists predominantly of birch plywood in Finland. These countries export significant quantities of solid wood products and fiber products, which is partially a function of their superior technology. Hence, in spite of the large volume of timber available in these countries, they still import substantial volumes of raw materials.

All of the models for Finland and Sweden incorporate stumpage prices (or wood delivered to roadside) and harvest and delivery costs separately. The estimated equations presented in this section refer exclusively to stumpage prices (or roadside) prices. For these regions, projections of harvest and delivery costs (or delivery costs) are determined exogenously.

The models presented in this section typically do not explain the harvest behavior in these regions very well, particularly prior to the last 10 years. However, given the structural change that has occurred in these markets, and our modeling objectives for the Pacific Rim Assessment model, we have judged these models to be adequate for this phase of the analysis. For recent publications that provide more extensive analyses of these markets, readers are referred to Kuuluvainen (1988) and Brannlund (1988).

5.2 Finland

Based on forest surveys conducted in different districts of Finland over the past decade, the land area currently classified as forest land is 20.1 mm ha (57% of this land is in the South). Total commercial fellings in 1986 were 38.5 mm m^3. The split between sawlogs and pulpwood was roughly equal. Softwood sawlog fellings totaled 17.0 mm m^3, compared to 1.3 mm m^3 of hardwood sawlogs. Softwood pulpwood fellings totaled 15.7 mm m^3, whereas hardwood pulpwood registered 4.3 mm m^3. The harvest of trees for fuelwood and miscellaneous uses has been negligible in recent years. All data in this section are from various editions of the Finland's "Yearbook of forest statistics," published by The Finnish Forest Research Institute.

5.2.1 Softwood Sawtimber Supply

Data on sawtimber harvests are based on reported receipts of domestic softwood logs at sawmills and plywood and veneer mills. These figures are then adjusted to account for sawlog exports. Lumber production drives the bulk of the harvest. Plywood and veneer mills have consumed only about 0.7 mm m^3 in recent years and sawlog exports have been in the 0.4 mm m^3 range. The price variable is real stumpage prices (in 1980 MK/m^3) in private forests by cutting season. We have designated the price for the cutting season to belong to the earlier calendar year; for example, the price for the 1986/1987 cutting season is associated with 1986. We have chosen this allocation based on our understanding that the price that is applicable in any cutting season is negotiated prior to the commencement of that season.

Figure 5.1 depicts the real sawtimber stumpage price and the cut-inventory ratio. The inventory variable includes the entire softwood growing stock and is based on the midpoints of the inventories that are reported for several periods. As noted earlier, the inventory has grown steadily over the last two decades.

Real sawtimber stumpage prices surged to an abrupt peak about 1973, and fell dramatically by 1975. Although prices have been somewhat erratic since that time, the general trend has been relatively flat. In contrast, the harvesting pattern has been highly cyclical since 1965. Harvesting rebounded sharply from the 1975 trough, and declined again in 1981-1982.

The cut-inventory ratio fell in 1986 and 1987, which contrasts sharply with the general harvesting pattern in North American regions. The cut-inventory ratio for softwood sawtimber lies in the 1-1.5% range.

A scatter plot showing the relationship between stumpage price and the cut-inventory ratio is shown in *Figure 5.2*. Three distinct periods appear in the graph: 1965-1972, 1973-1976, and 1977-1987. For the estimation of the final equation, we have eliminated the first two periods as being irrelevant over the forecast horizon. As we observed previously, there has very little response in the price dimension in recent years, in spite of large quantity shifts. Hence, stumpage supply appears to be quite elastic. The final equation (*Figure 5.3*) indicates the value of the elasticity is 2.9.

5.2.2 Softwood Pulpwood Supply

Data on softwood pulpwood harvests are based on reported receipts of domestic softwood pulpwood logs at pulp mills, particleboard mills, and fibreboard mills. These figures are then increased to account for pulpwood log exports. Particleboard and fibreboard mills consumed only a small fraction of pulpwood logs historically, and registered zero consumption in 1987. In 1987, pulpwood log exports amounted to less than 5% of the harvest destined for pulp mills. Since pulpwood exports are not disaggregated by species, softwood and hardwoods shares were based on relative production levels.

The price variable is the real stumpage price for pulpwood logs (in 1980 MK/m^3) in private forests by cutting season. As before, we have allocated the cutting season price to the earlier calendar year. The price is computed from pine and spruce prices assuming that each species accounts for 50% of the total.

Figure 5.4 depicts the real pulpwood stumpage price and the cut-inventory ratio between 1970 and 1987. As with softwood sawtimber markets, the price does not exhibit the same volatility as the quantity variable. However, in contrast to sawtimber markets, real prices have been gradually rising since the late 1970s.

The relationship between stumpage price and cut-inventory has been quite unpredictable, as indicated in the scatter plot shown in *Figure 5.5*.

As with sawtimber, we isolated the 1977-1987 period to determine the elasticity that is relevant over the forecast period. The final equation, shown in *Figure 5.6*, indicates that the elasticity of softwood roundwood pulpwood supply with respect to the stumpage price is 2.8. The elasticities for softwood pulpwood stumpage and softwood sawtimber stumpage are essentially the same.

5.2.3 Hardwood Sawtimber and Pulpwood Supply

Data on hardwood sawtimber and pulpwood harvests and prices are derived in the same manner as for softwood. In contrast to the softwood sawtimber market, the vast majority of hardwood sawtimber in consumed in veneer and plywood production, rather than lumber. In 1987, this share approached 90%.

We had limited success in modeling these markets. Our initial attempt to understand behavioral patterns in the hardwood sawtimber stumpage market led to a supply elasticity of 0.9. Since hardwood sawtimber markets in Finland are quite small, we did not attempt to extend this analysis. Examination of the scatter plot for hardwood pulpwood suggested that supply has been perfectly elastic in recent years. Thus, we decided to treat this market as exogenous.

5.3 Sweden

Based on Swedish forest surveys conducted during 1983-1986, the estimated area of forest land in Sweden is 23.7 mm ha. Although the land area is only about 20% greater than that of Finland, total commercial fellings are over 50% higher. The majority of the harvest (about 80%) is softwood. The share of roundwood pulpwood harvested is greater than that of sawtimber, about 55% to 45% in 1986. Very little of the hardwood harvest is consumed in solid wood manufacturing: hardwoods comprised only 1% of the sawnwood industry in 1986. Production of veneer and plywood is negligible in Sweden. All data in this section are from various editions of the Sweden's "Statistical Yearbook of Forestry," published by The National Board of Forestry.

5.3.1 Softwood Sawtimber Supply

Data on sawtimber harvests are based on consumption of logs at sawmills and veneer and plywood mills, with appropriate adjustments for foreign trade. As noted earlier, harvest levels are essentially governed by lumber production. The price variable is the real delivered roadside price (in 1980 SEK/m^3) by cutting season. Following the same convention as for Finland, we have allocated the cutting season price to the earlier calendar year.

The real sawtimber roadside price and the cut-inventory ratio are plotted in *Figure 5.7.* The inventory variable, which measures the entire softwood growing stock has expanded rapidly in recent years. *Figure 5.8* presents a scatter plot of the price and cut-inventory variables. A major structural shift appears to have occurred in 1975. Although the relationship between these two variables is quite unstable since that time, there is some evidence of a classical supply relationship. The final equation is presented in *Figure 5.9*. We estimate that the elasticity of softwood sawtimber supply with respect to the roadside price is 0.4.

5.3.2 Softwood Pulpwood Supply

Softwood pulpwood harvests are computed from roundwood consumption at pulp mills, particleboard mills, and fibreboard mills. These figures are adjusted by net trade, which is a very important factor in Sweden. Softwood roundwood pulpwood imports totaled 4.3 mm m^3 in 1986, which represented approximately 16% of total softwood roundwood pulpwood consumption in that year. The price variable is the real delivered roadside price for pulpwood logs (in 1980 SEK/m^3), which is constructed as a volume-weighted average of pine and spruce prices.

Figure 5.10 depicts the real pulpwood stumpage price and the cut-inventory ratio between 1971 and 1987. Unlike in Finland, the percent of the inventory being harvested in the past decade has not returned to the levels of the early 1970s. This is partly due to the increased reliance on imports during this time. Real prices appear to have been relatively stable over the past decade.

Figure 5.11 presents the scatter plot of prices against the cut-inventory ratio. The relationship has shifted radically during the historical period. Although the relationship has been erratic since 1975, it appears that there are sufficient data to approximate the pulpwood supply curve. The final equation, shown in *Figure 5.12*, indicates the supply elasticity with respect to the delivered roadside price is 1.0.

5.3.3 Hardwood Pulpwood Supply

Data on hardwood pulpwood harvests and prices are derived in the same manner as for softwood. As with Sweden, it was difficult to discern a clear pattern in the historical data. Using 7 recent observations, we estimated a supply elasticity of 1.0. Since the Swedish hardwood pulpwood market is of limited importance in the Pacific Rim Assessment, we decided that this estimate would suffice.

Figures 5.1-5.3: **Finland - Softwood Sawtimber**: Relationship between stumpage price (**P**) in 1980 MK/m^3 and cut-inventory ratio (**CI**)

Figure 5.1 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

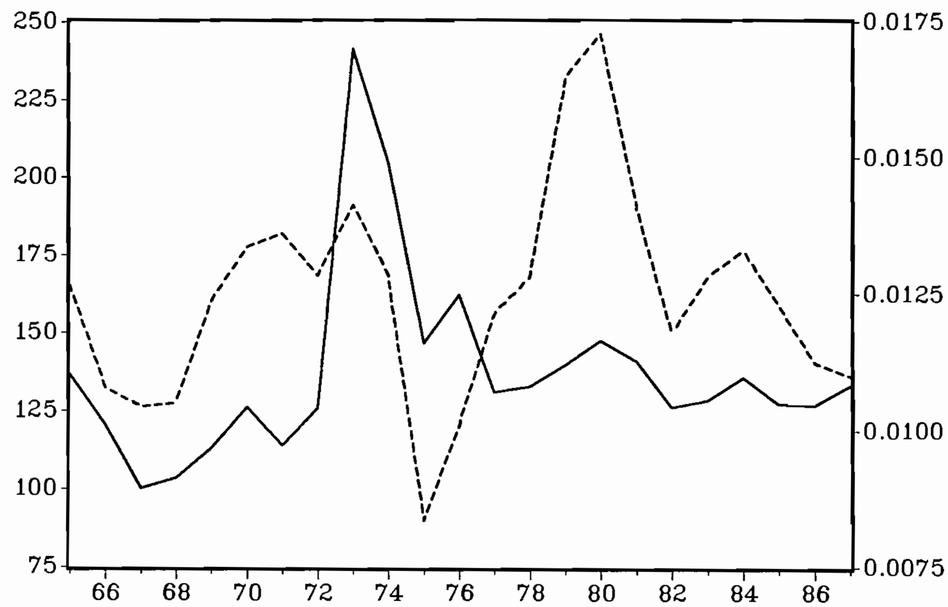


Figure 5.2 Scatter plot of **P** against **CI**

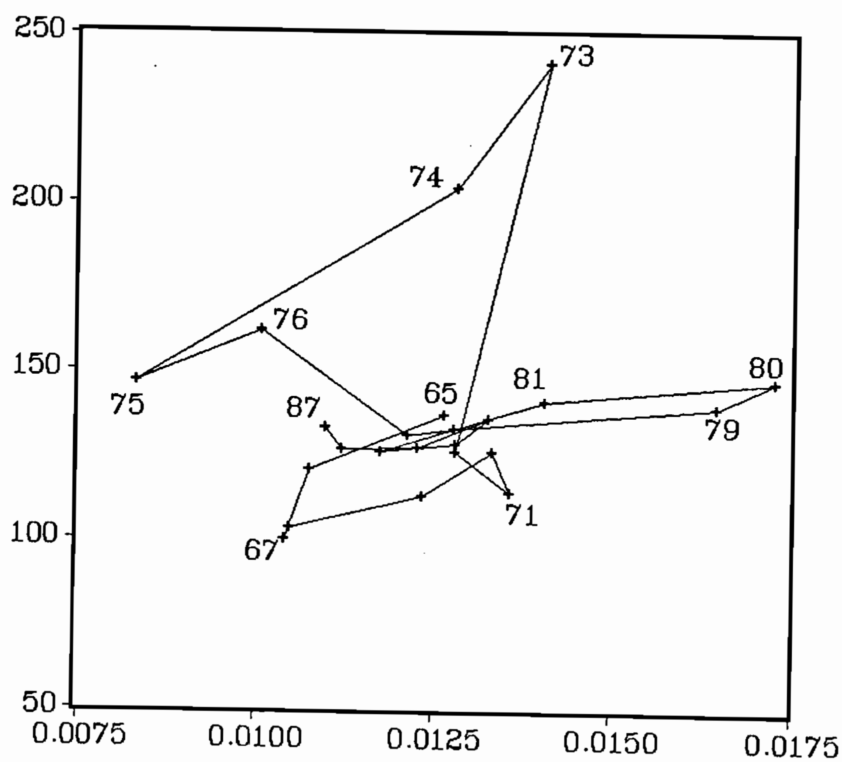


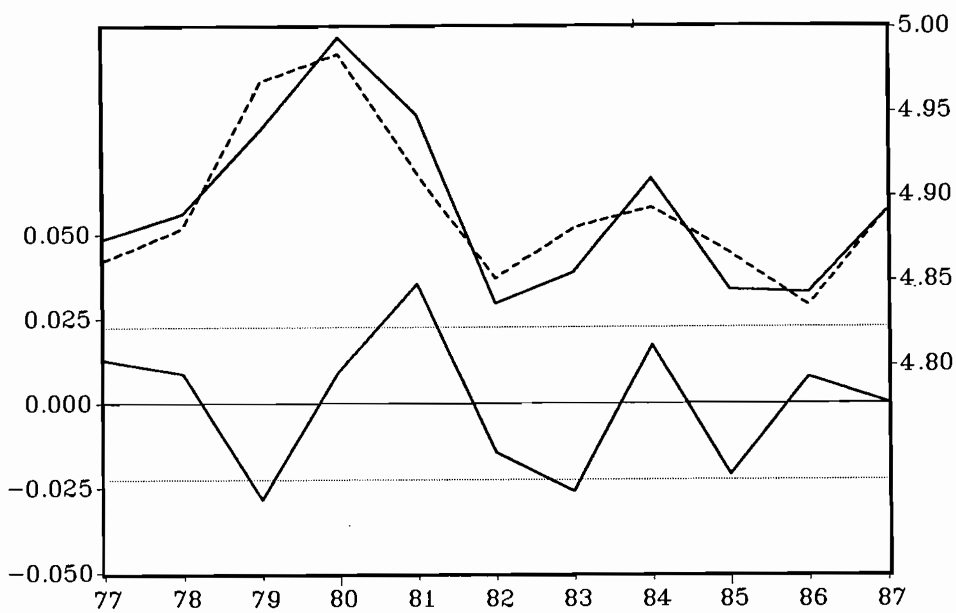
Figure 5.3 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1977 - 1987
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	6.3933882	0.2310110	27.675692	0.000
LN (CI)	0.3472114	0.0534431	6.4968439	0.000
D87	0.0640656	0.0258303	2.4802447	0.038

R-squared	0.840695	Mean of dependent var	4.893058
Adjusted R-squared	0.800869	S.D. of dependent var	0.050694
S.E. of regression	0.022622	Sum of squared resid	0.004094
Durbin-Watson stat	2.538806	F-statistic	21.10912
Log likelihood	27.82052		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 5.4-5.6: **Finland - Softwood Roundwood Pulpwood:** Relationship between stumpage price (**P**) in 1980 MK/m^3 and cut-inventory ratio (**CI**)

Figure 5.4 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

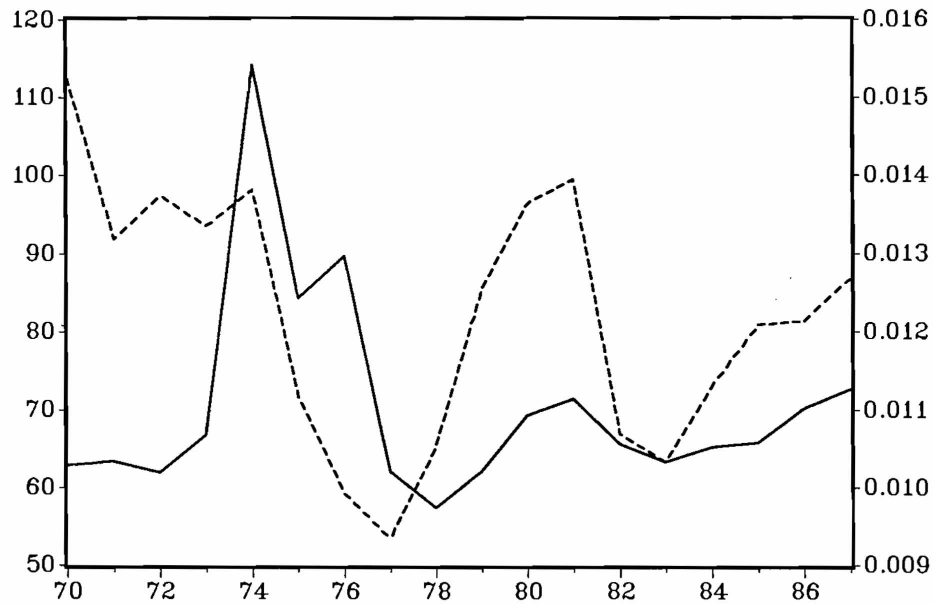


Figure 5.5 Scatter plot of **P** against **CI**

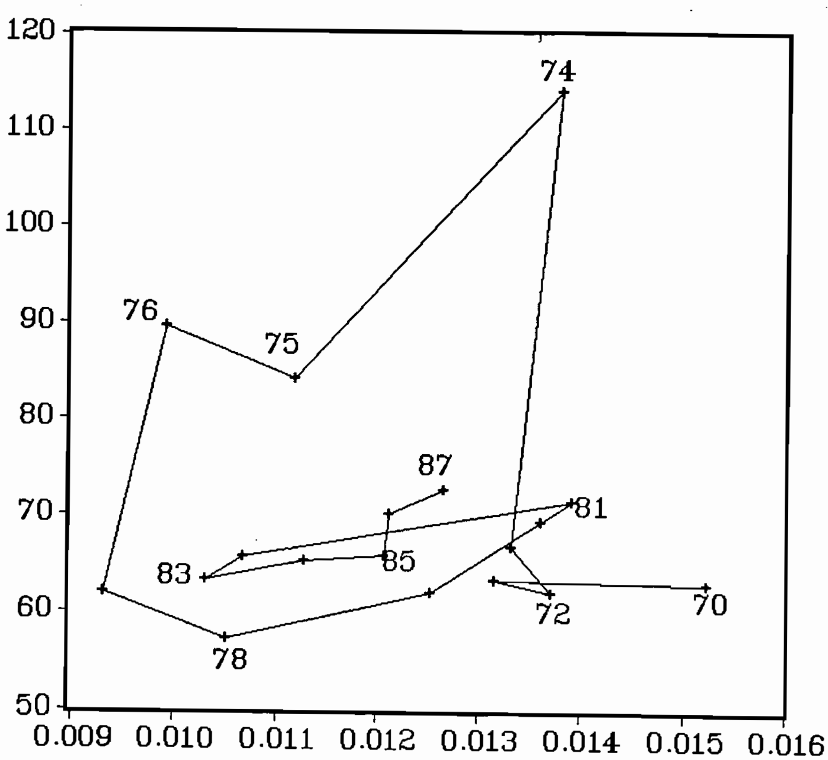


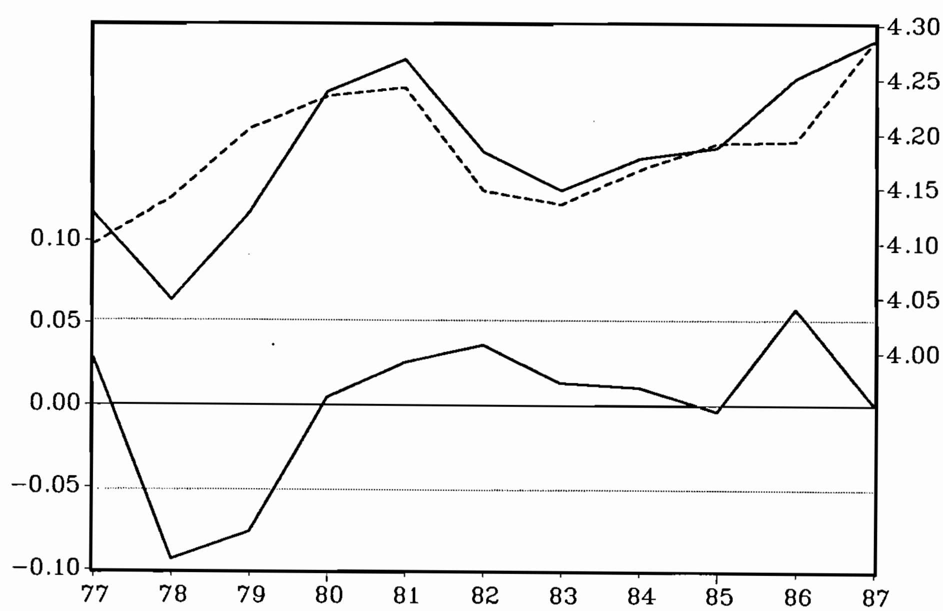
Figure 5.6 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1977 - 1987
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	5.7714410	0.5980362	9.6506551	0.000
LN (CI)	0.3578083	0.1340449	2.6693162	0.028
D87	0.0765478	0.0553861	1.3820751	0.204

R-squared	0.584241	Mean of dependent var	4.185643
Adjusted R-squared	0.480302	S.D. of dependent var	0.071406
S.E. of regression	0.051477	Sum of squared resid	0.021199
Durbin-Watson stat	1.435401	F-statistic	5.620965
Log likelihood	18.77606		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 5.7-5.9: **Sweden - Softwood Sawtimber**: Relationship between roadside price (**P**) in 1980 SEK/m^3 and cut-inventory ratio (**CI**)

Figure 5.7 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

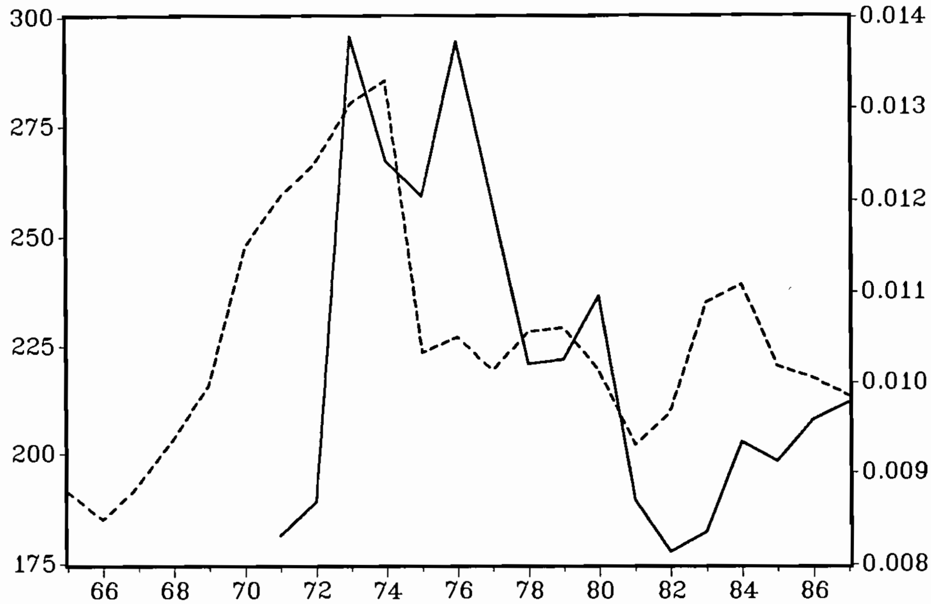


Figure 5.8 Scatter plot of **P** against **CI**

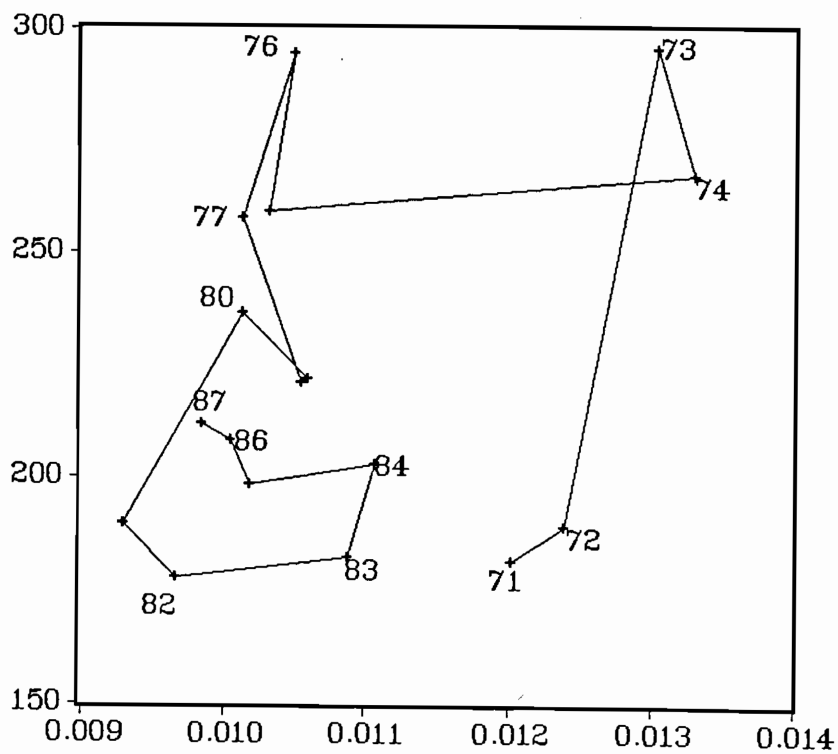


Figure 5.9 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1975 - 1987
Number of observations: 13

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	16.733729	4.1874947	3.9961194	0.003
LN (CI)	2.4655896	0.9114244	2.7052046	0.022
D8384	-0.3518679	0.1163142	-3.0251502	0.013

R-squared	0.502613	Mean of dependent var	5.383349
Adjusted R-squared	0.403135	S.D. of dependent var	0.149082
S.E. of regression	0.115176	Sum of squared resid	0.132655
Durbin-Watson stat	1.357237	F-statistic	5.052533
Log likelihood	11.35597		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis

Figures 5.10-5.12: **Sweden - Softwood Roundwood Pulpwood:** Relationship between roadside price (**P**) in 1980 SEK/m^3 and cut-inventory ratio (**CI**)

Figure 5.10 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

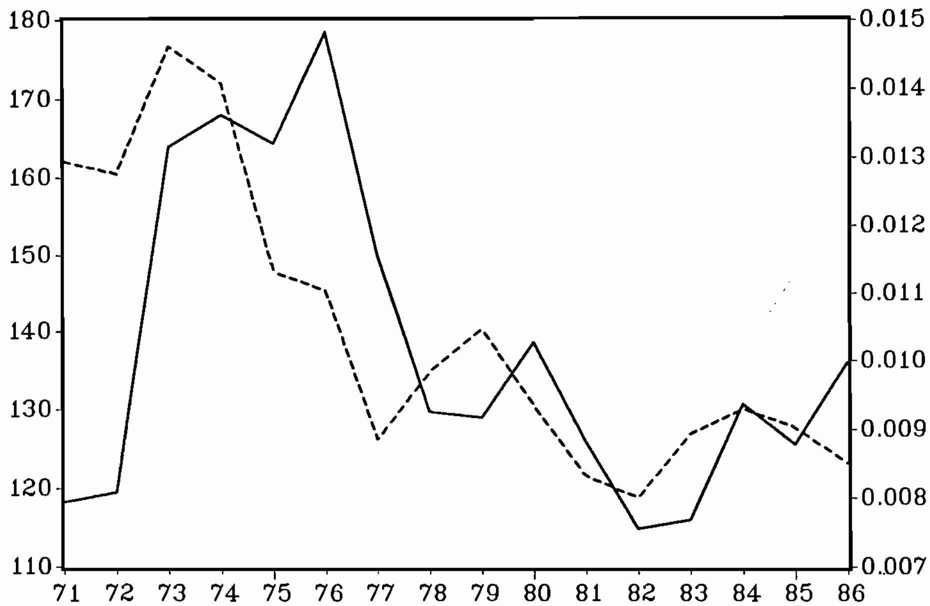


Figure 5.11 Scatter plot of **P** against **CI**

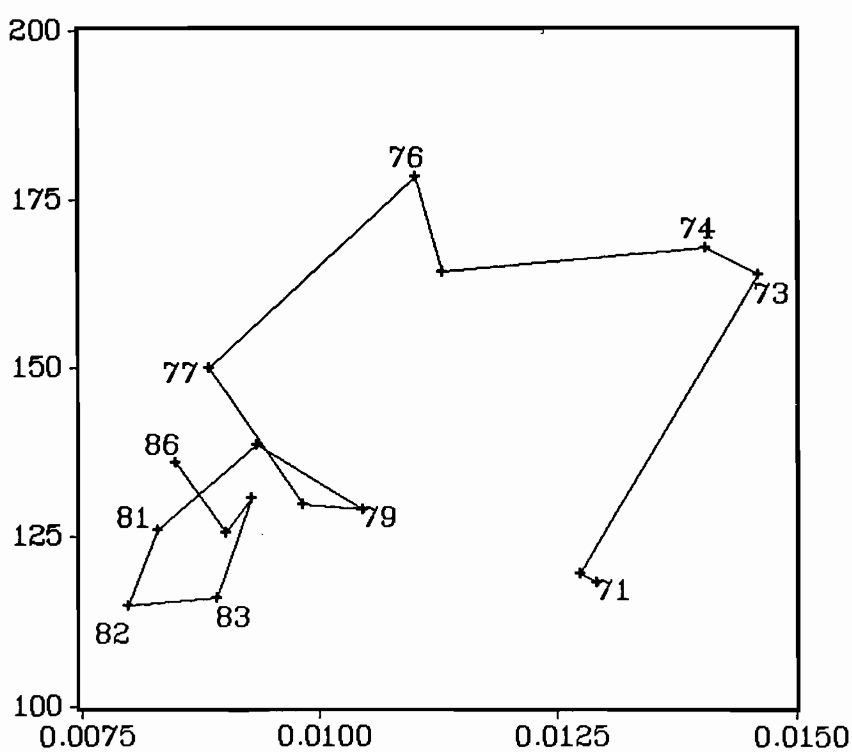


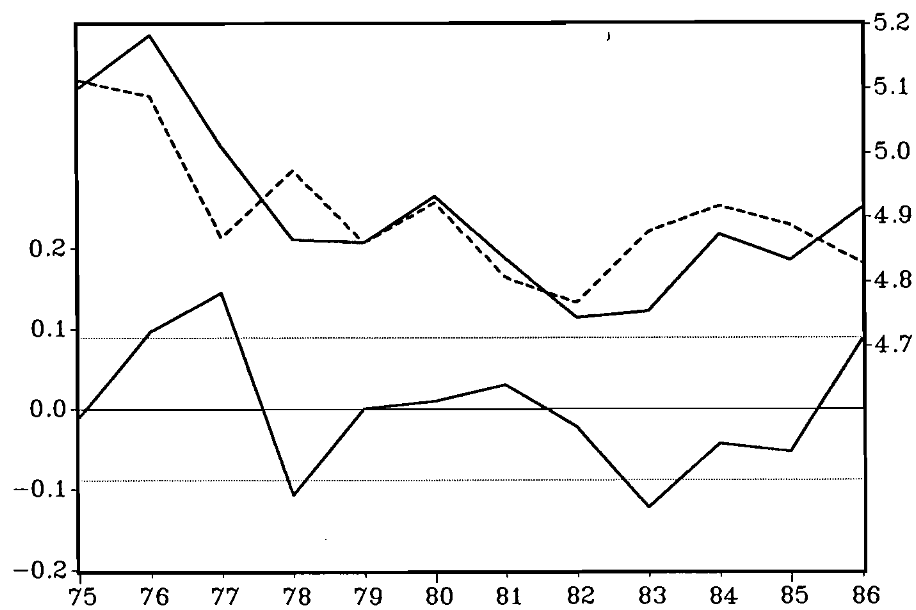
Figure 5.12 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1975 - 1986
Number of observations: 12

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	9.5994313	1.2004140	7.9967671	0.000
LN (CI)	1.0009256	0.2563214	3.9049634	0.004
D79	-0.1765275	0.0976779	-1.8072405	0.104

R-squared	0.633910	Mean of dependent var	4.908555
Adjusted R-squared	0.552556	S.D. of dependent var	0.132342
S.E. of regression	0.088525	Sum of squared resid	0.070530
Durbin-Watson stat	1.819290	F-statistic	7.792047
Log likelihood	13.79248		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



6. JAPAN

6.1 Overview

Japan's forest industry occupies a unique position in the Pacific Rim due to its voluminous appetite for wood and its heavy dependence on imported timber. But Japan's supply situation is changing rapidly.

Japan is a heavily forested country: 2/3's, or 25.26 mm ha, of its total land area is classified as forest area. Although the forest land area has remained unchanged for the past two decades, there has a dramatic conversion from natural stands to plantations. Land in plantations now totals 10.2 mm ha, and accounts for 40% of the forest area. (In contrast, the estimated area of land in plantations in the U.S. South was 8.5 mm ha in 1985.) The Government of Japan's target area for plantations is 11.5 mm ha (Diet Report, 1987), so they have almost accomplished their goal. Of the total plantation area, 59% consists of 16-35 year old stands. Less than 10% of the plantations have reached harvestable age, but because of the large area involved, they contribute significantly to the current harvest. Although we do not have exact data on the harvest of plantation wood, data on the species mix of the harvest suggest that more than 50% of the domestic softwood harvest now comes from plantations. Plantations are 99% softwood species.

The allocation of total forest land by ownership is: private owners, 58%; provincial owners, 11 %; and, national 31%. The government places operational restrictions on protection forests, which total 8.4 mm ha (only half of the protection forests are part of the national forests).

As of 1986, the total growing stock in Japan was 2.86 billion m^3, which reflects a 50% increase from 1966. Growing stock volume on man-made forests was 1.36 billion m^3, or 48% of the total. The remaining 1.50 billion m^3 is in natural stands, of which 44% exceed 50 years old, and 2/3's are comprised of hardwood species. The government's target growing stock is 3.9 billion m^3. In the latest five years, the annual increment of the growing stock was 76 mm m^3. Most of the volume increase is due to the rapid growth of plantations in the younger age classes. In the next 10 to 20 years, a large volume of plantation timber, ranging from 80 to 150 mm m^3 per year, will become mature and available for harvest.

Japan produced between 31 and 33 mm m^3 annually in the 1981-1986 period. This represents a 40% reduction from the 1967 peak of 52 mm m^3. Most of the reduction has occurred on private forests. Two reasons for the decline in timber production were: 1) shortages of forest workers that resulted in high labor costs; and, 2) increased competition from overseas producers. By ownership, 36% of the total harvest comes from public forests (30% national, 6% provincial) and 64% from the private sector.

In the recent years, Japanese cedar (Sugi) and Japanese cypress (Hinoki) have increased their share of domestic sawlog production relative to other softwood species and hardwoods. This trend is likely to continue in the future since 2/3's of plantations are comprised of Japanese cedar and Japanese cypress, and many of the stands of indigenous species are inside the protection forests. As far as roundwood pulpwood is concerned, over 70% of the harvest consists of hardwood species, and these originate almost entirely from natural stands.

The model used for Japanese softwood sawtimber incorporates stumpage costs and harvest and delivery costs separately. Although harvest decisions by private and public forest owners may differ, we have aggregated these two sectors due to the lack of data needed to model these independently and our lack of knowledge concerning institutional factors that influence public behavior. The supply of hardwood sawtimber, softwood pulpwood, and hardwood pulpwood are modeled on a delivered basis.

6.2 Softwood Sawtimber Supply

The harvest of softwood sawlogs and veneer logs has decreased substantially over the last two decades. Much of the decrease occurred during the period 1967-1975, as production fell from 28.5 mm m^3 to 17.6 mm m^3. Nearly all domestic sawtimber is used by sawmills. A small amount of Japanese cypress and pine is used for plywood manufacturing.

Data on sawtimber harvests are reported by the Japanese Forestry Agency, and appear in a number of publications such as the "Japan Lumber Journal." Prices of stumpage and delivered sawlogs were obtained from Japanese government publications. The average prices of stumpage and sawlogs are calculated based on the following species weights: Japanese cedar, 0.55; Japanese cypress, 0.25; and, Japanese pine 0.20. These weights were determined from log production shares and information available concerning the construction of Bank of Japan price indexes. All prices are deflated using the wholesale price index in Japan.

6.2.1 Softwood Sawtimber Stumpage Supply

Figure 6.1 depicts the real sawtimber stumpage price in 1980 000 yen/m^3 and the cut in million m^3. Real stumpage prices declined substantially during the period 1970-1987, and except for increases in 1973, 1986, and 1987, the decline was steady. The general trend in harvesting reflects this pattern of price behavior. The lack of cyclical movements in these series makes it difficult to interpret the relationship between price and harvest. We ruled out the use of the cut-inventory ratio because the age-class structure of Japan's forest is such that increases in inventory have not had a large effect on the availability of mature timber; therefore, the inclusion of total growing stock would not be appropriate in this model.

A scatter plot showing the relationship between stumpage price and cut is shown in *Figure 6.2*. There is clear evidence that a major shift in softwood stumpage markets occurred between 1973 and 1974. The final model was estimated using the 1974-1987 sample. The regression results and fit are shown in *Figure 6.3.* The elasticity of softwood sawtimber supply with respect to the stumpage price is 0.27.

6.2.2 Softwood Sawtimber Harvest and Delivery Costs

Sawlog harvest and delivery costs were derived by subtracting stumpage prices from prices of sawlogs delivered to the mill. The harvest and delivery cost share of delivered prices has been in the 40-45% range. The high stumpage price share is unique among countries in East and Southeast Asia: in Southeast Asian countries, stumpage prices usually comprise less than 10% of the delivered sawlog price. While the high stumpage share in Japan may be partially explained by high product values and locational factors, government harvesting subsidies also play an important role. In 1985, the Japanese Government spent 68 billion yen on forest road subsidies (Handa, 1988). The subsidy rate for forest roads amounts to 45-65% of road construction costs.

Harvest and delivery costs for softwood sawtimber, in 1980 000 yen/m^3, are shown in *Figure 6.4*. Two distinct peaks are apparent in 1973 and 1979, and the lowest costs were incurred in 1984. This pronounced cyclicality is unusual for harvest and delivery cost behavior, and may be due to swings in profitability in the logging sector. A scatter plot between harvest and delivery costs and cut is shown in *Figure 6.5*. As in the stumpage case, there was a significant shift in behavior between the early and mid-1970s. Since 1974, there appears to have been a very stable relationship between real harvest and delivery costs and harvest levels. The estimated equation and fit are shown in *Figure 6.6*. The elasticity of softwood sawtimber supply with respect to harvest and delivery costs is 0.24, which is very close to that of stumpage supply.

6.2.3 Softwood Sawlog Supply

Because of the similarity of the response of sawtimber supply to stumpage price and to harvest and delivery costs, an alternative model of Japanese softwood sawtimber supply was estimated. In this model, delivered sawlog prices are directly related to sawtimber harvest levels. The historical trends in the softwood sawlog price (in 1980 000 yen/m^3) and cut are shown in *Figure 6.7*. A scatter plot between the two variables is provided in *Figure 6.8*. The final equation, presented in *Figure 6.9*, indicates that the elasticity of softwood sawtimber supply with respect to the delivered price is 0.25.

6.3 Hardwood Sawtimber Supply

The production of hardwood sawlogs decreased from 5.9 mm m^3 in 1970 to 2.5 mm m^3 in 1987, while the real price increased 80% over the same period. The main reason for the lack of responsiveness of hardwood sawtimber supply to price increases appears to be resource availability. Hardwood harvests come mainly from old-growth natural stands, and the accessible growing stock is declining because these stands are being protected for nontimber benefits. Information on the commercially-available old-growth volume was not available.

We attempted to measure hardwood sawtimber supply behavior by creating a proxy variable for the available old-growth inventory. The initial growing stock was assumed to equal 200 mm m^3 in 1965; this value was selected to reflect the protection of a significant portion of natural stands. After that time, changes in the old-growth inventory were assumed to be due only to harvest reductions: additions due to growth were assumed to be insignificant, and additional set-asides were ignored. The cut-inventory ratio created using these data is plotted in *Figure 6.10*, along with the delivered price of hardwood sawlogs (measured in 1980 000 yen/m^3). A scatter plot between these two variables is presented in *Figure 6.11*. An equation for the hardwood sawlog price was estimated over the 1974-1987 period. Due to the apparent inward shifts in this curve over time, three intercept dummies were included in the model. The estimated equation and the fit are shown in *Figure 6.12*. This regression indicates that the elasticity of hardwood sawtimber supply with respect to the delivered price is 0.39.

Due to obvious structural changes in the hardwood sawtimber market, this exercise was only experimental and the parameters suggested by the final equation are not very reliable. Since scarcity of Japanese hardwood sawtimber is likely to increase in the future regardless of the price, we will likely treat this market as exogenous in our model simulations.

6.4 Softwood Pulpwood Supply

Softwood pulpwood consumption in Japan increased from 8.5 mm m^3 in 1967 to 15.6 mm m^3 in 1987. Of the total consumption in 1987, 90% was received as woodchips and nearly half of this volume was imported. Although total softwood pulpwood consumption nearly doubled over this period, production of pulpwood from roundwood sources decreased from 3.9 mm m^3 in 1967 to 3.0 mm m^3 in 1987. These data are somewhat higher than the data on softwood roundwood pulpwood harvest (3.0 mm m^3 in 1967 and 1.5 mm m^3 in 1987) because a substantial volume of roundwood pulpwood is converted to chips prior to arrival at the pulp mill site.

The historical trends in the price of softwood roundwood pulpwood delivered to the mill (measured in 1980 000 yen/m^3), and the cut-inventory variable are shown in *Figure 6.13*. Total softwood inventory is used to shift the supply curve since small-diameter trees and plantation thinnings can be sold to pulp mills. The scatter plot (*Figure 6.14*) suggests the expected relationship between these two variables. The final equation was estimated over the period 1970 to 1987, with intercept dummies for 1973 and 1982-1985. The estimated equation and the fit are presented in *Figure 6.15*. The elasticity of softwood roundwood pulpwood supply with respect to the delivered price is 1.75.

6.5 Hardwood Pulpwood Supply

Hardwood pulpwood consumption in Japan increased from 12.6 mm m^3 in 1967 to 16.7 mm m^3 in 1987. However, the domestic hardwood pulpwood harvest decreased from 10.2 mm m^3 in 1967 to 8.2 mm m^3 in 1987. Only 1% of the total pulpwood furnish was actually received in roundwood form: nearly all of domestic and foreign hardwood pulpwood is converted into woodchips before arriving at pulp mills.

The historical trends in the price of pulpwood delivered to the mill (in 1980 000 yen/m^3) and cut-inventory variables are shown in *Figure 6.16*. The cut is measured by the pulpwood harvest, regardless of the site where it is chipped. The inventory is the total hardwood growing stock in natural stands, since very little hardwood is grown in plantation forests. The relationship between the two variables of interest is shown in the scatter plot in *Figure 6.17*. The final equation (see *Figure 6.18*) was estimated over the period 1973-1987, with an intercept dummy for the 1986-1987 period. The elasticity of hardwood roundwood pulpwood supply with respect to the delivered price is 1.69, which is almost identical to the elasticity estimated for softwoods.

Figures 6.1-6.3: **Japan - Softwood Sawtimber:** Relationship between stumpage price (**P**) in 1980 000 YEN/m^3 and cut in million m^3 (**Q**)

Figure 6.1 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

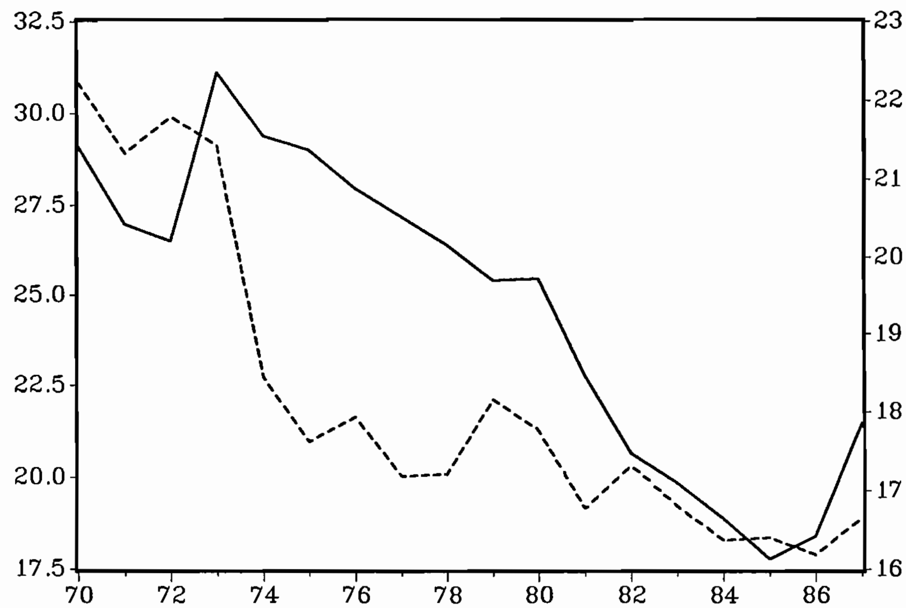


Figure 6.2 Scatter plot of **P** against **Q**

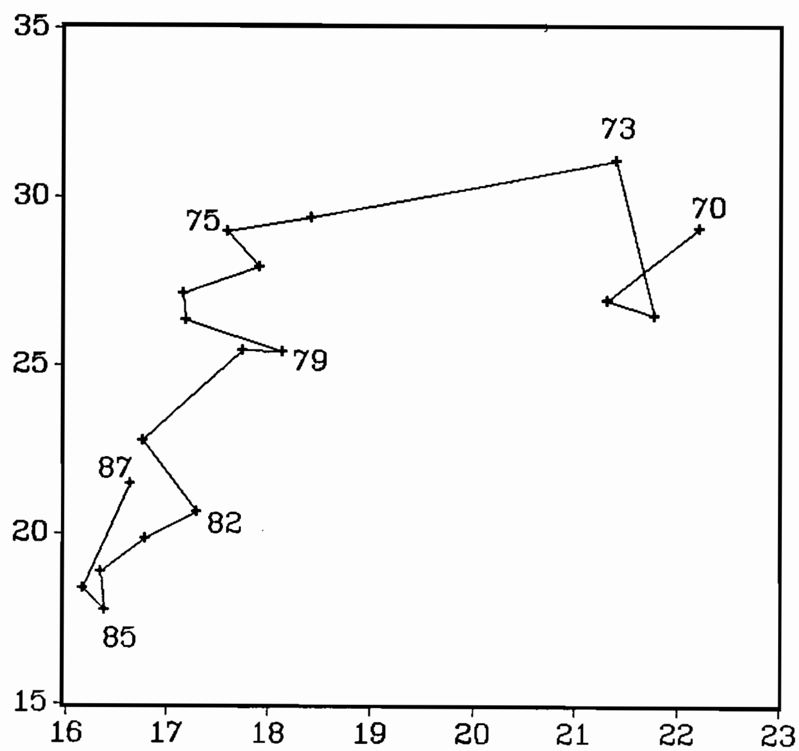


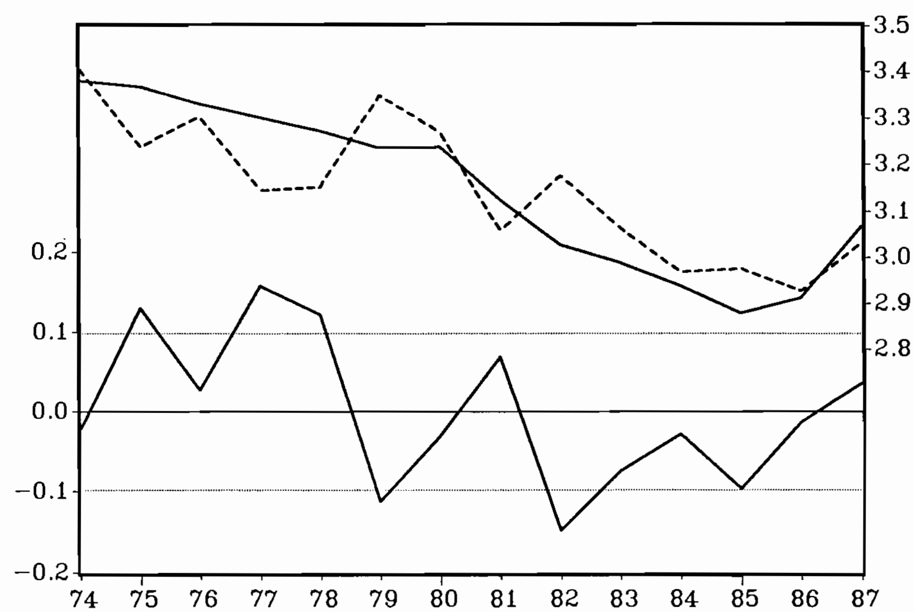
Figure 6.3 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1974 - 1987
Number of observations: 14

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-7.2945244	1.8827712	-3.8743552	0.002
LN (Q)	3.6717817	0.6620306	5.5462420	0.000

R-squared	0.719369	Mean of dependent var	3.146767
Adjusted R-squared	0.695983	S.D. of dependent var	0.177936
S.E. of regression	0.098110	Sum of squared resid	0.115507
Durbin-Watson stat	1.670045	F-statistic	30.76080
Log likelihood	13.71726		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 6.4-6.6: **Japan - Softwood Sawtimber:** Relationship between harvest and delivery cost (**HD**) in 1980 000 YEN/m^3 and cut in million m^3 (**Q**)

Figure 6.4 Historical trends in **HD** (solid line, left axis) and **Q** (dashes, right axis)

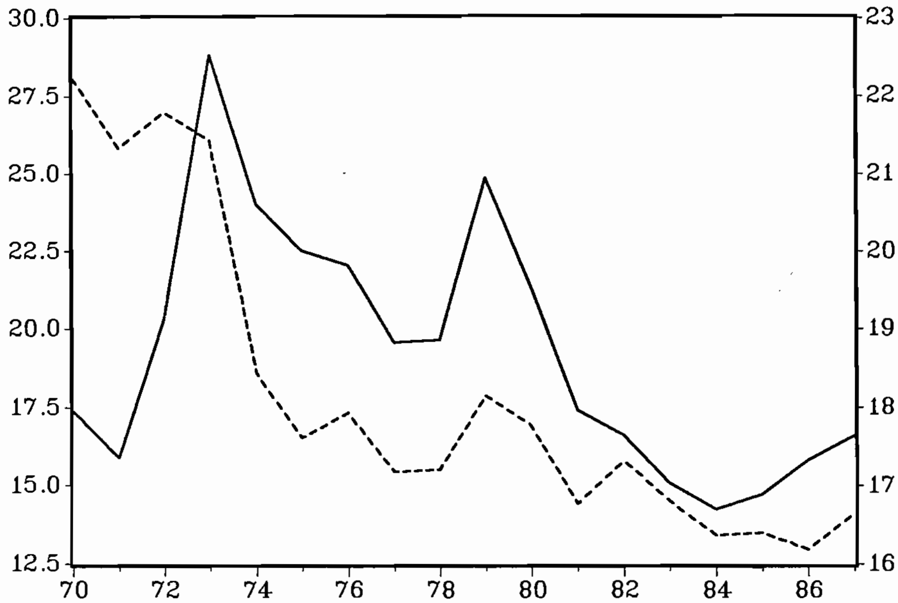


Figure 6.5 Scatter plot of **HD** against **Q**

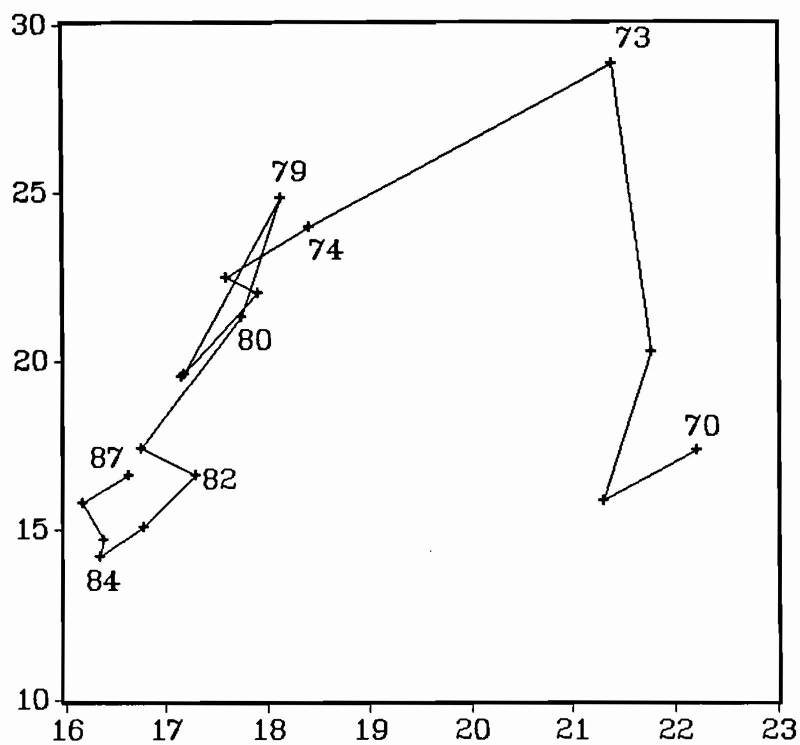


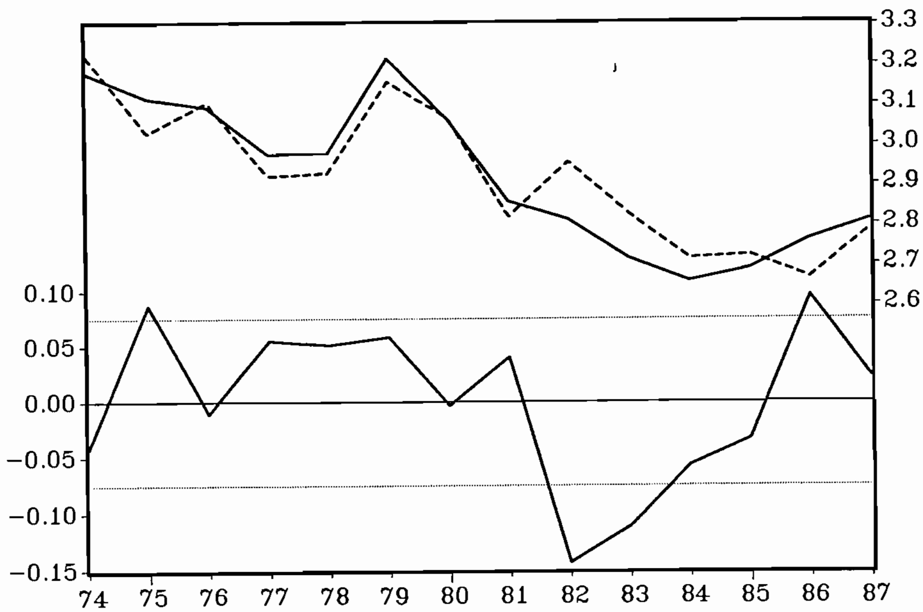
Figure 6.6 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (HD)
SMPL range: 1974 - 1987
Number of observations: 14

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-9.1786607	1.4398294	-6.3748253	0.000
LN (Q)	4.2550237	0.5062809	8.4044723	0.000

R-squared	0.854783	Mean of dependent var	2.921172
Adjusted R-squared	0.842682	S.D. of dependent var	0.189163
S.E. of regression	0.075028	Sum of squared resid	0.067551
Durbin-Watson stat	1.441602	F-statistic	70.63516
Log likelihood	17.47234		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 6.7-6.9: **Japan - Softwood Sawtimber:** Relationship between delivered price (**P**) in 1980 000 YEN/m^3 and cut in million m^3 (**Q**)

Figure 6.7 Historical trends in **P** (solid line, left axis) and **Q** (dashes, right axis)

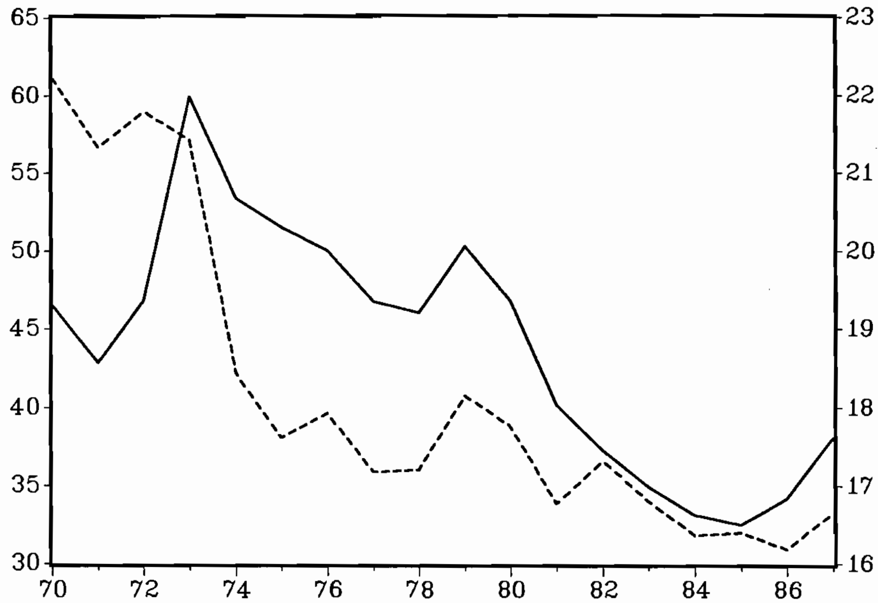


Figure 6.8 Scatter plot of **P** against **Q**

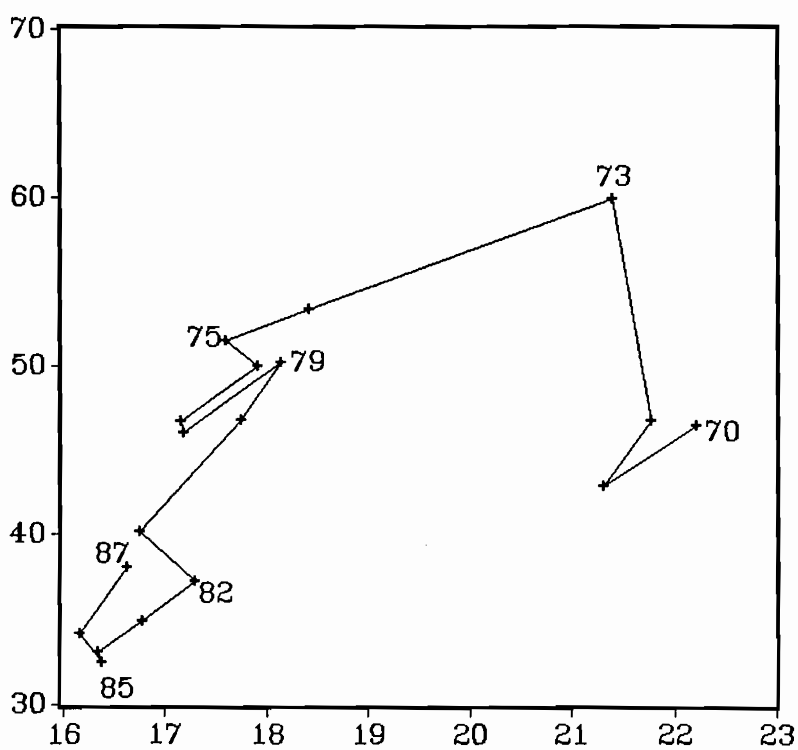


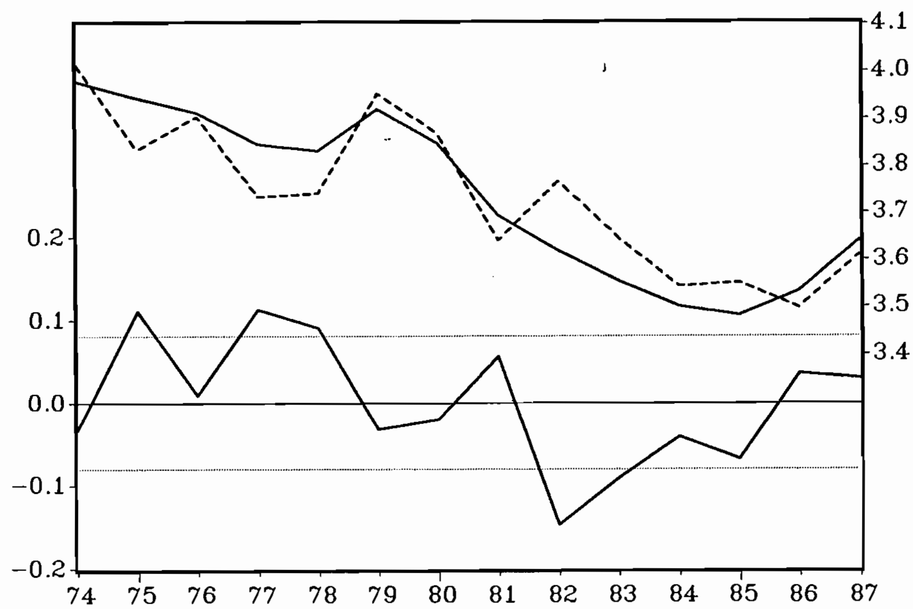
Figure 6.9 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1974 - 1987
Number of observations: 14

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-7.4709873	1.5403125	-4.8503061	0.000
LN (Q)	3.9403908	0.5416133	7.2752838	0.000

R-squared	0.815185	Mean of dependent var	3.734137
Adjusted R-squared	0.799784	S.D. of dependent var	0.179380
S.E. of regression	0.080265	Sum of squared resid	0.077309
Durbin-Watson stat	1.574032	F-statistic	52.92975
Log likelihood	16.52789		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 6.10-6.12: **Japan - Hardwood Sawtimber:** Relationship between delivered price **(P)** in 1980 000 YEN/m^3 and cut-inventory ratio **(CI)**

Figure 6.10 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

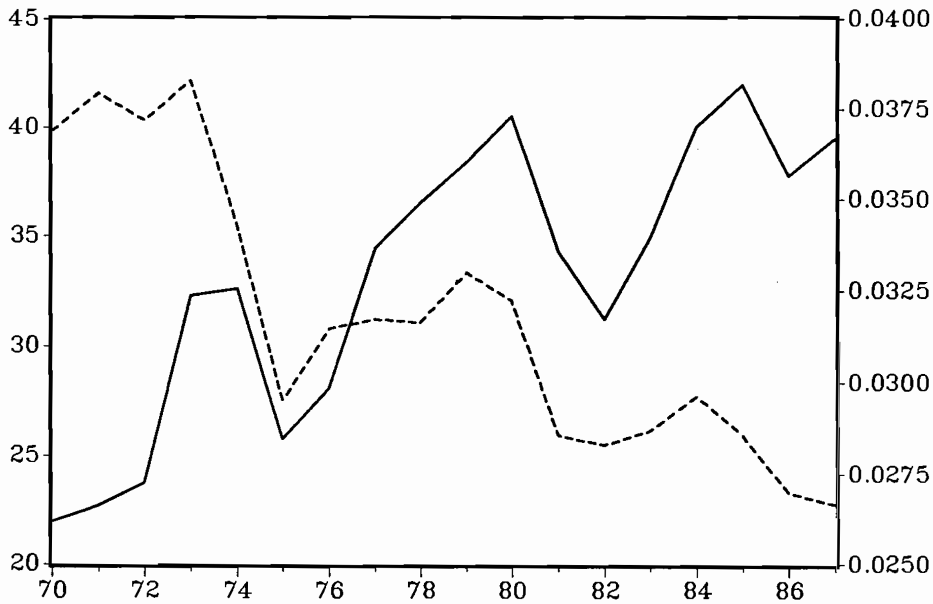


Figure 6.11 Scatter plot of **P** against **CI**

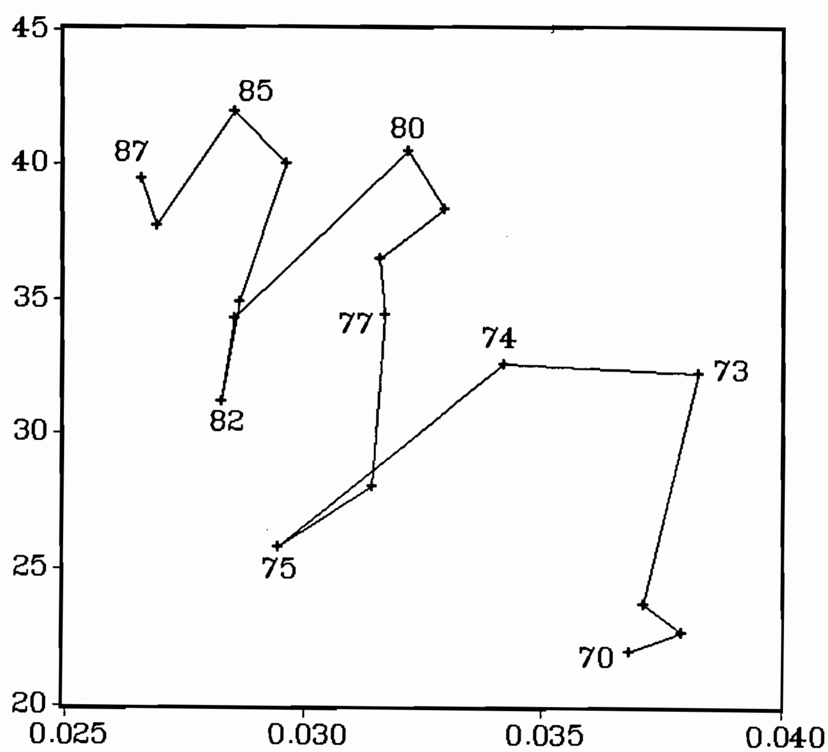


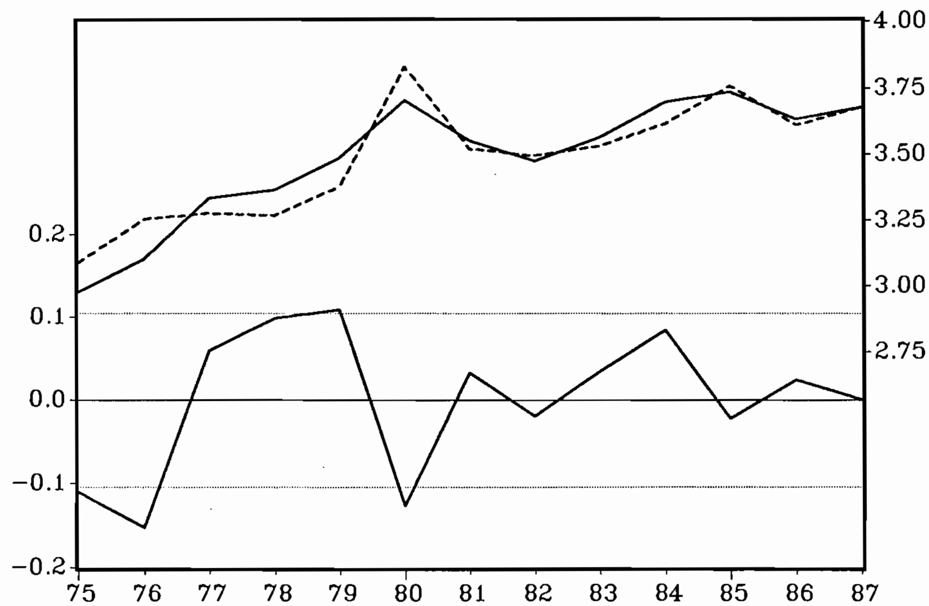
Figure 6.12 Regression results and plot of residual, actual, and fitted values

```
LS // Dependent Variable is LN (P)
SMPL range: 1975  -  1987
Number of observations: 13
```

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	12.228580	2.5846949	4.7311502	0.001
LN (CI)	2.5952480	0.7469169	3.4746142	0.008
D8084	0.5165206	0.0821381	6.2884402	0.000
D8586	0.7555362	0.1276949	5.9167315	0.000
D87	0.8562473	0.1684820	5.0821306	0.001

R-squared	0.870190	Mean of dependent var	3.481547
Adjusted R-squared	0.805286	S.D. of dependent var	0.236236
S.E. of regression	0.104243	Sum of squared resid	0.086932
Durbin-Watson stat	1.737158	F-statistic	13.40719
Log likelihood	14.10305		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 6.13-6.15: **Japan - Softwood Roundwood Pulpwood:** Relationship between delivered price (**P**) in 1980 000 YEN/m^3 and cut-inventory ratio (**CI**)

Figure 6.13 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

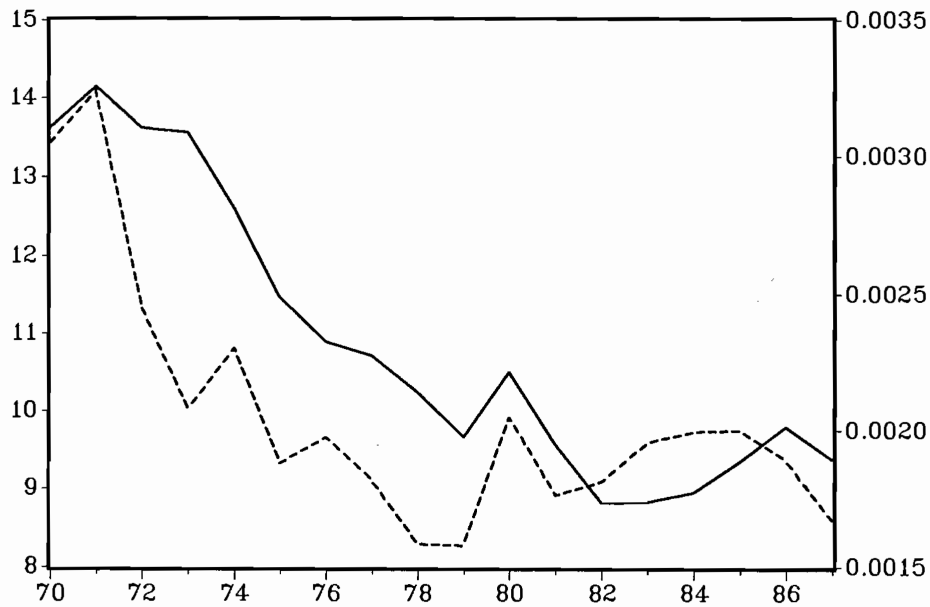


Figure 6.14 Scatter plot of **P** against **CI**

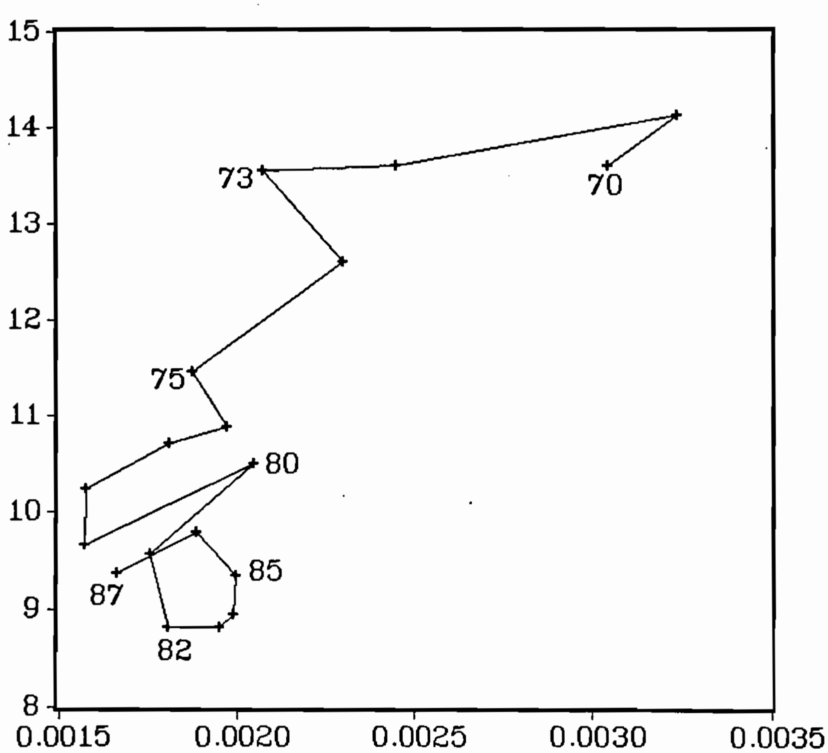


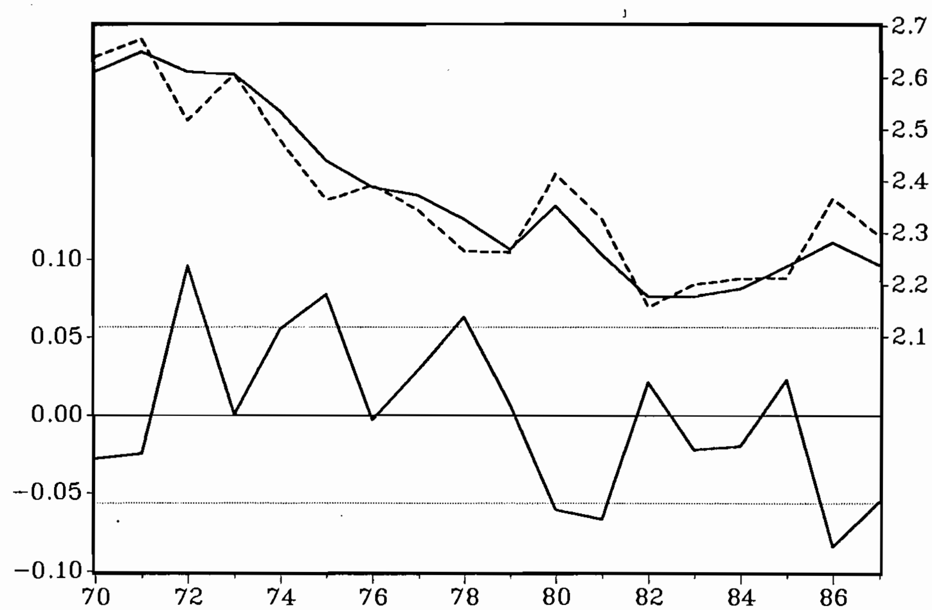
Figure 6.15 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1970 - 1987
Number of observations: 18

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	5.9529741	0.4331591	13.743158	0.000
LN (CI)	0.5719713	0.0698751	8.1856223	0.000
D73	0.1865621	0.0585706	3.1852491	0.007
D8285	-0.1850791	0.0324645	-5.7009760	0.000

R-squared	0.902331	Mean of dependent var	2.372849
Adjusted R-squared	0.881402	S.D. of dependent var	0.163853
S.E. of regression	0.056428	Sum of squared resid	0.044577
Durbin-Watson stat	1.505664	F-statistic	43.11380
Log likelihood	28.46722		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 6.16-6.18: **Japan - Hardwood Roundwood Pulpwood:** Relationship between delivered price (**P**) in 1980 000 YEN/m^3 and cut-inventory ratio (**CI**)

Figure 6.16 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

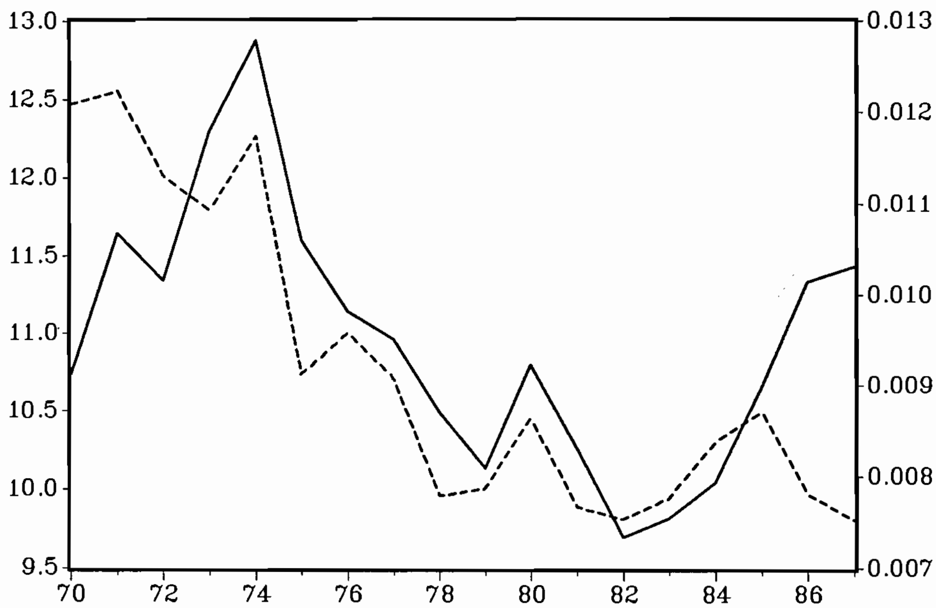


Figure 6.17 Scatter plot of **P** against **CI**

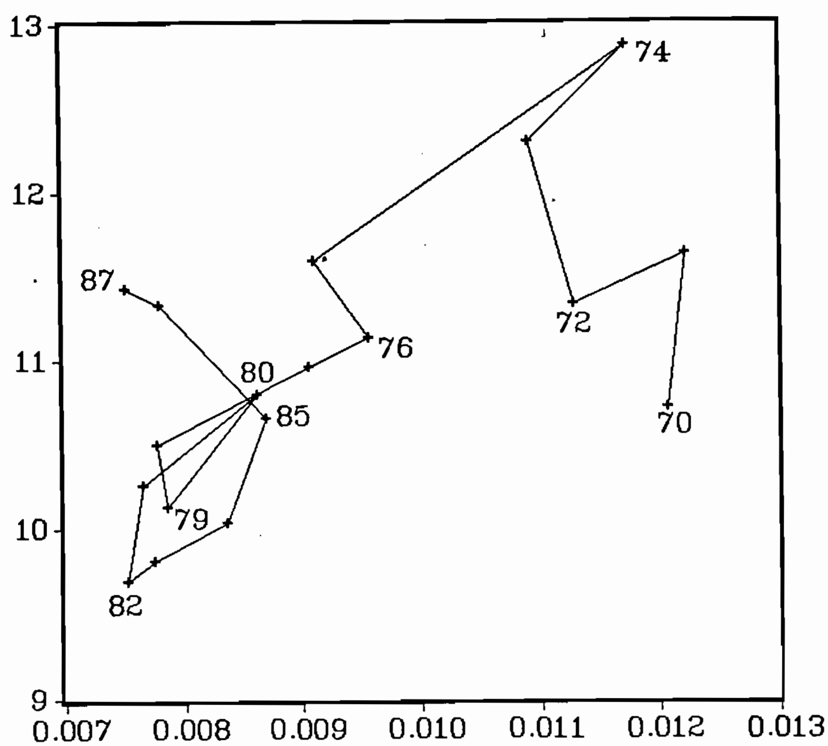


Figure 6.18 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1973 - 1987
Number of observations: 15

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	5.1736044	0.2731283	18.942028	0.000
LN (CI)	0.5913865	0.0577661	10.237606	0.000
D8687	0.1325445	0.0222432	5.9588719	0.000

R-squared	0.902714	Mean of dependent var	2.385621
Adjusted R-squared	0.886499	S.D. of dependent var	0.081494
S.E. of regression	0.027455	Sum of squared resid	0.009046
Durbin-Watson stat	1.821320	F-statistic	55.67354
Log likelihood	34.31742		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis

7. SOUTHEAST ASIA

7.1 Overview

For the purposes of the Pacific Rim Assessment, we define Southeast Asia as Indonesia, East Malaysia, West Malaysia, Papua New Guinea, and the Philippines. The forest resources of this region are almost entirely tropical hardwood rainforests. Genera in the family Dipterocarpaceae dominate forests in regions west of the "Wallace Line" (East and West Malaysia, Philippines, and western Indonesia), while a more diverse and historically less valuable mixture of species is found in regions to the east (Papua New Guinea and eastern Indonesia). Based on 1987 estimates, Indonesia has nearly 2/3's of the growing stock in the region, followed by Papua New Guinea and East Malaysia with slightly more than 10% each.

Commercial exploitation of the South Seas forests has expanded rapidly since the early 1960s, as logging proceeded from the Philippines to (in approximate order) West Malaysia, Sabah (in East Malaysia), Indonesia, Sarawak (in East Malaysia), and Papua New Guinea. Increase in harvests from current levels are generally felt to be possible only in Indonesia and Papua New Guinea. In East Malaysia, potential harvest increases in Sarawak are likely to be offset by reductions in Sabah.

Initial exploitation in all regions occurred in lowland forests. Today, most harvesting takes place in hill forests, which tend to be more difficult to log, more poorly stocked, and more problematic to regenerate than the lowland forests. Although the nominal hill forest management system in most regions is a selective system, poor control of harvesting intensities, high rates of logging damage, and invasion by shifting cultivators frequently result in the bulk of the growing stock on a site being either removed or destroyed. Thus, production from second-growth forests remains insignificant, except in West Malaysia where it appears that harvests are split more or less evenly between virgin and second-growth forests.

With the exception of Papua New Guinea, all natural forest land in the South Seas is publicly owned, either by state (East and West Malaysia) or federal (Indonesia, Philippines) governments. Forests in Papua New Guinea are communally owned. Rights to harvest timber in all regions are granted via timber concession agreements. Concessions are allocated on the basis of social or political patronage rather than by a competitive process such as bidding. Concession contracts range from a few months to 50 years, with most being 10 to 20 years long. Concessionaires, who are frequently mill owners, tend to subcontract logging operations to independent logging firms.

Governments' interests in exploiting their forest resources are driven by objectives to raise revenue and foreign exchange and to open up land for agricultural and industrial development. Government charges on timber fall into two general categories: 1) royalties, which are assessed on logs extracted from the forest, and 2) premiums, which are assessed on the area of forest logged. Royalties are the more significant of the two charges, and their level is related directly or indirectly to delivered log prices. The total fee paid to governments falls substantially below true stumpage values. The discrepancy is larger for timber processed domestically, because most governments grant royalty rebates on such timber. In log-exporting regions, government revenue is also collected from export taxes, which further contributes to the differences observed between exported log prices and domestic log prices.

West Malaysia began restricting the export of logs in the early 1970s. Similar actions were taken by the Philippines in the late 1970s and Indonesia in the early 1980s. These policies were motivated by the desire to induce more domestic processing (Indonesia) and by concerns about the adequacy of domestic log supplies (West Malaysia and the Philippines). The restrictions culminated in log export embargoes by West Malaysia and Indonesia in 1985 and by the Philippines in 1986. Due to the embargoes, East Malaysia and Papua New Guinea are now the only significant log exporters in Southeast Asia.

Log supply concerns have motivated the establishment of plantations of fast-growing hardwood pulpwood and sawlog species in all regions. The increasing scarcity of supply in West Malaysia also has induced the expanded utilization of rubberwood. It appears unlikely that plantations will be a significant source of sawlogs before 2000 in any region. Rubberwood, however, could potentially comprise up to a third of West Malaysia's timber supply in the 1990s, providing raw material for sawnwood used in domestic construction and the manufacture of furniture for export markets.

Timber supply models for Southeast Asian regions have two components: 1) harvest and delivery costs, or **net delivered price**, which is defined as the delivered price of logs minus government charges assessed on these logs; and, 2) the fees levied by government. Net delivered prices are modeled as a marginal cost curve based on the assumption that timber concessionaires maximize profits by minimizing their harvesting and delivery costs, irrespective of the timber charges per output predetermined by the government.

In the short run, harvest and delivery costs would be expected to increase with increasing harvest, due to factors of production that are essentially fixed, such as logging equipment. The cost curve would shift upward due to increases in factor prices for variable inputs, such as labor and energy. Because the infrastructure in the South Seas regions tends to be poorly developed, the short-run cost curve would also shift upward as logging proceeds to more distant and more difficult sites. Increases in logging costs that arise from the depletion of old-growth stands tend to be correlated with the decline in inventory, or the decline in virgin forest area. Several alternative model specifications were tested for these regions, and special attention was given to explaining the observed rate of timber exploitation. Because much of the initial expansion into remote areas appears to be well underway, the models can be greatly simplified by the judicious selection of the sample period used for estimation. In the models presented in this section, net delivered prices are modeled as a function of the cut-inventory ratio.

All data used in the model pertain to tropical hardwoods. Data on forest resources were based on point estimates for individual years, which were extended over the entire sample using an inventory model developed specifically for these regions. "Inventory" refers to the growing stock (industrial stemwood net of defect) of all hardwood species of merchantable size (above 45-50 cm DBH, depending on the region). In the Philippines, inventory includes only Dipterocarp species, because it was possible to disaggregate this group from the total growing stock. The terms "harvest" and "cut" refer to log removals, that is, logs actually extracted from the forest. Harvests were set equal to the maximum of: 1) reported log production, or 2) derived log production based on the sum of logs exported and logs consumed in sawnwood and panels manufacturing.

Delivered log prices were assumed to be equal to export unit values (adjusted to account for export duties where necessary), except in West Malaysia where weighted domestic prices were used for 1971-1986. Data on royalties were generally available for all regions, but data on premiums (area-based timber charges) were available only for West Malaysia. All prices are expressed in domestic currencies and were converted to real terms (1980 base year) by using a general price deflator (the wholesale price index was used for Indonesia and the Philippines, and the consumer price index was used for East and West Malaysia and Papua New Guinea).

7.2 Indonesia

Indonesia is the world's second largest producer of tropical hardwoods (after Brazil). In 1987, closed productive forest land totaled 94 mm ha, and the inventory of commercially-merchantable tropical hardwood was estimated to be approximately 4.6 billion m^3. Log production is almost exclusively hardwood sawtimber.

Log production has increased dramatically over the past three decades. In 1960, Indonesia produced only 3.8 mm m^3 of sawlogs, and this total had climbed to a peak of 28.8 mm m^3 by 1979. Over the same time frame, we estimate that the inventory fell from 5.5 to 5.0 billion m^3.

Before the log export restriction policy was adopted in 1980, Indonesian hardwood log production was driven mostly by log export demand. In 1970, 69% of the total log production of 11.4 mm m^3 was exported. The fraction of harvest that went directly to export peaked at 80% in 1973 (the total harvest was 23.0 mm m^3). During the record production year of 1979, 62% of total production was destined for export markets. Log export restrictions became increasing stringent between 1980 and 1985, at which time a complete log export ban become effective. Log production now depends entirely on the domestic production of lumber and plywood. Log production declined after the restrictions went into effect, but recovered to 27.4 mm m^3 by 1986.

The historical trends in Indonesian net delivered hardwood log prices, expressed in 1980 rupiah/m^3, and the cut-inventory ratio are shown in *Figure 7.1*. Unlike the trend in most sawtimber prices, the collapse in real prices after 1980 was not sustained. We determine prices using export unit values; hence, the real price increases were most likely due to the export restrictions and the increasing **share** of high-quality logs in the export mix. This price rebound results in a clear upward trend in real prices over the entire historical period. The sharp increase in the cut-inventory ratio between 1968 to 1979 came to an abrupt halt in the early 1980s. The 1986 cut-inventory level just barely exceeded the estimated 1979 level. Note that the level is still quite low compared to that observed for many other regions: in the 1980s, producers in Indonesia have been cutting only 0.5% of the available inventory.

A scatter plot between the net delivered log price and the cut-inventory ratio (*Figure 7.2*) provides the expected supply relationship. In spite of the low level of the cut-inventory relationship, we do not anticipate a significant outward shift in the supply curve. A dramatic increase in real prices would be required to open up new timberland areas due to both the poorer species mix of the untapped inventory and its location.

The final equation was estimated over the 1968-1986. The regression results and the fit are shown in *Figure 7.3*. An intercept dummy was used for the 1977-1978 period to account an acceleration of logging that we attribute to the anticipation of log export restrictions. The elasticity of hardwood sawtimber supply is with respect to the net delivered price is 0.92.

7.3 East Malaysia

Malaysia is comprised of 13 states -- Sabah, Sarawak, and 11 states on Peninsula (West) Malaysia. Though forest management and resource utilization policies differ among states, the most critical distinction exists between those states in West Malaysia and East Malaysia (Sabah and Sarawak). Selective cutting is strictly enforced in West Malaysia and there is a ban on the export of unprocessed logs. On the other hand, harvest systems in East Malaysia are less strictly regulated and the vast majority of logs that are produced are directly exported. For these reasons, these two regions are modeled separately in the Pacific Rim Assessment.

The production of hardwood sawtimber in East Malaysia has expanded dramatically since 1960: hardwood sawlog production increased from 3.3 mm m^3 in 1960 to 24.8 mm m^3 in 1987 (note that the absolute levels are roughly similar to those of Indonesia). Higher harvesting rates have caused a substantial reduction in growing stock volumes, from 1.9 billion m^3 in 1960 to 830 mm m^3 in 1987. In recent years, approximately 90% of log production is shipped to foreign markets without being processed.

Figure 7.4 depicts the historical trends in net delivered log prices (in 1980 ringgits/m^3), and the cut-inventory ratio. Real prices were relatively stable from 1968 to 1978, surged in 1979, and declined in the early 1980s. Though prices appear to have stabilized again in the 1980s, the level is significantly higher than that of the 1970s. In sharp contrast to this pattern, the rapid increases in the cut-inventory ratio have continued almost unabated throughout this period. About 2.7% of the inventory is now being harvested each year, a rate which is 4-5 times that in Indonesia.

The scatter plot shown in *Figure 7.5* does not depict a particularly clear pattern of behavior. We interpret this diagram as suggesting that the supply relationship is still fairly responsive to price changes, although the pattern is quite erratic. *Figure 7.6* presents the final equation and its fit. We use 2 dummy variables to account for the outliers. This equation suggests that the elasticity of hardwood sawtimber supply with respect to the net delivered price is 2.21.

7.4 West Malaysia

As in East Malaysia, the production of hardwood logs increased rapidly from 1960 (2.2 mm m^3) to 1987 (10.3 mm m^3). This has caused a 50% reduction West Malaysia's merchantable hardwood sawtimber growing stock, which we estimate equaled 500 mm m^3 in 1987. Unlike the other regions of Southeast Asia, West Malaysia's harvests come from both virgin and second-growth forests.

The historical trend in the net delivered hardwood sawlog price (in 1980 ringgits/m^3) is shown in *Figure 7.7*, along with the cut-inventory ratio. The price has been highly volatile, and has continued on a downward trend in recent years. The rapid increases in the cut-inventory ratio that we observe in the 1970s had ceased by the early 1980s.

The scatter plot between the two relevant variables (*Figure 7.8*) suggests that there has been two major supply shifts during this period. We restrict the estimation sample to 1974-1986, and include an intercept dummy to account for the shift that commenced in 1982. The regression results and fit are provided in *Figure 7.9*. The elasticity of hardwood sawtimber supply with respect to the net delivered price is 0.91, which is virtually identical to the elasticity we found for Indonesia.

7.5 Papua New Guinea

Unlike the other major regions of Southeast Asian, the exploitation of forest resources in Papua New Guinea (PNG) has been minimal. Our estimate of the 1987 hardwood growing stock over 45 cm DBH is about 855 mm m^3 in 1987. Although the growing stock exceeds that of East and West Malaysia, the production of hardwood logs reportedly was only 1.7 mm m^3 in 1986 (up from 0.5 mm m^3 in 1970). We do not anticipate that harvesting will accelerate rapidly in the fashion observed in other Southseas regions for two reasons: 1) PNG is not rich in Dipterocarp species; and, 2) institutional factors make timber exploitation difficult because the forests are communally owned. More than 80% of the roundwood produced is exported as raw logs. We also expect this trend to continue due to the low population in PNG, and hence the low level of demand for finished products, and the lack of capital that would be necessary for investment in manufacturing facilities.

Net delivered prices (in 1980 kina/m^3) and the cut-inventory ratio are shown in *Figure 7.10*. The pattern of real prices shows some similarity to that of East Malaysia. Although the cut-inventory has been rising steadily over time, only 0.2% of the inventory is being cut each year. *Figure 7.11* provides the scatter plot between the price and cut-inventory ratio. The final model (*Figure 7.12*) was estimated over the 1972-1986 period, with an intercept dummy included for 1979-1980. Based on this regression, the elasticity of hardwood sawtimber supply with respect to the net delivered price is 1.64.

7.6 Philippines

The exploitation of the indigenous forest resources of the Philippines began much earlier than in the other regions of Southeast Asia. Hardwood sawtimber production peaked in 1969 at 12.5 mm m^3 and has subsequently declined, primarily due to resource depletion. The inventory of Dipterocarp timber -- the major source of sawtimber harvests -- decreased from 600 mm m^3 in 1960 to 350 mm m^3 in 1987. Since the log export ban became fully effective in 1986, sawtimber production now depends entirely on the production of plywood and lumber.

The historical trend of the net delivered hardwood sawtimber price (in 1980 pesos/m^3) is shown in *Figure 7.13*, along with the cut-inventory ratio. The cut-inventory ratio has fallen significantly, from 0.025 in the early 1970s to 0.010 in 1986. This pattern of decline is unique among the regions of Southeast Asia. The relationship between price and cut-inventory is shown in the scatter plot in *Figure 7.14*. The final equation and its fit is presented in *Figure 7.15*. We eliminated the period prior to 1976, and included an intercept dummy for 1976-1978. This model indicates that the elasticity of hardwood sawtimber supply with respect to the net delivered price is 1.20.

Figures 7.1-7.3: **Indonesia - Hardwood Sawtimber:** Relationship between net delivered price (**P**) in 1980 RUP/m^3 and cut-inventory ratio (**CI**)

Figure 7.1 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

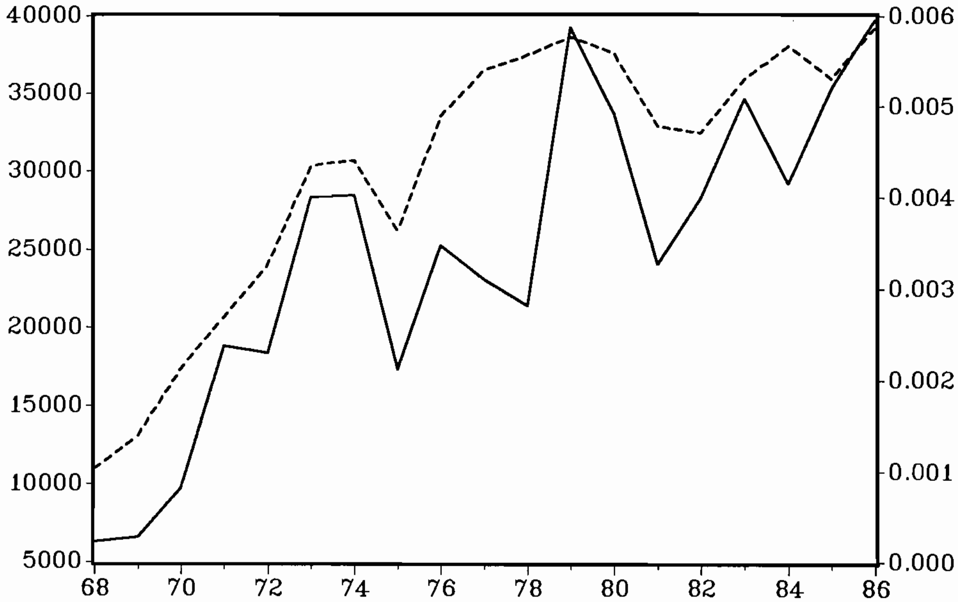


Figure 7.2 Scatter plot of **P** against **CI**

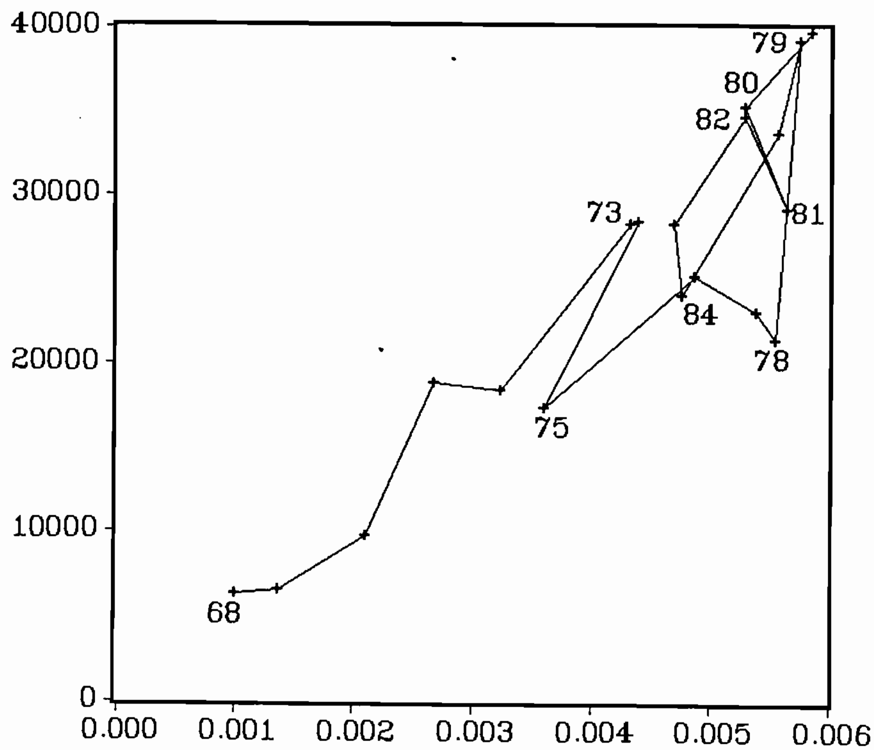


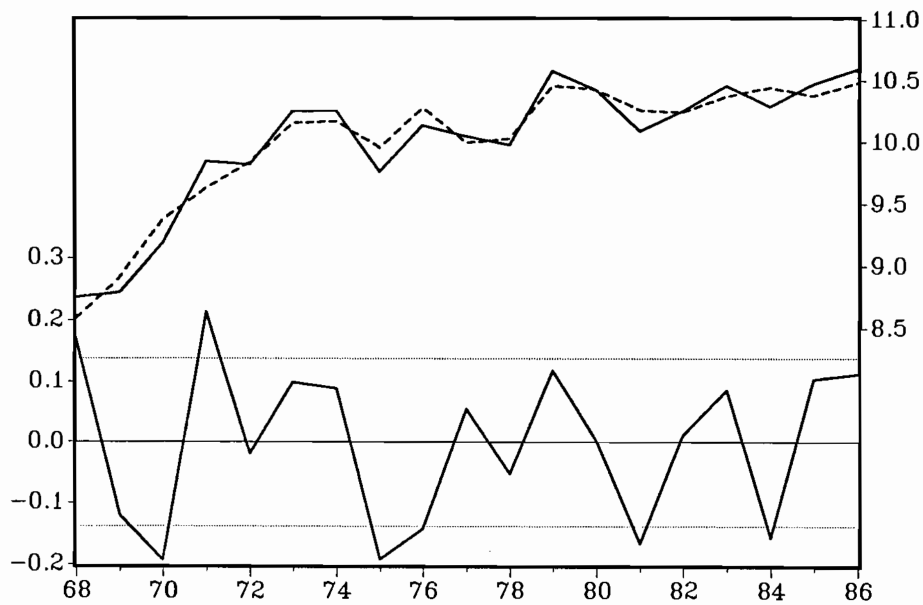
Figure 7.3 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1968 - 1986
Number of observations: 19

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	16.059698	0.3720562	43.164715	0.000
LN (CI)	1.0861457	0.0663527	16.369283	0.000
D7778	-0.3942723	0.1061898	-3.7129009	0.002

R-squared	0.943657	Mean of dependent var	9.995649
Adjusted R-squared	0.936614	S.D. of dependent var	0.548397
S.E. of regression	0.138068	Sum of squared resid	0.305004
Durbin-Watson stat	2.265408	F-statistic	133.9866
Log likelihood	12.29293		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 7.4-7.6: **East Malaysia - Hardwood Sawtimber:** Relationship between net delivered price (**P**) in 1980 RNG/m^3 and cut-inventory ratio (**CI**)

Figure 7.4 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

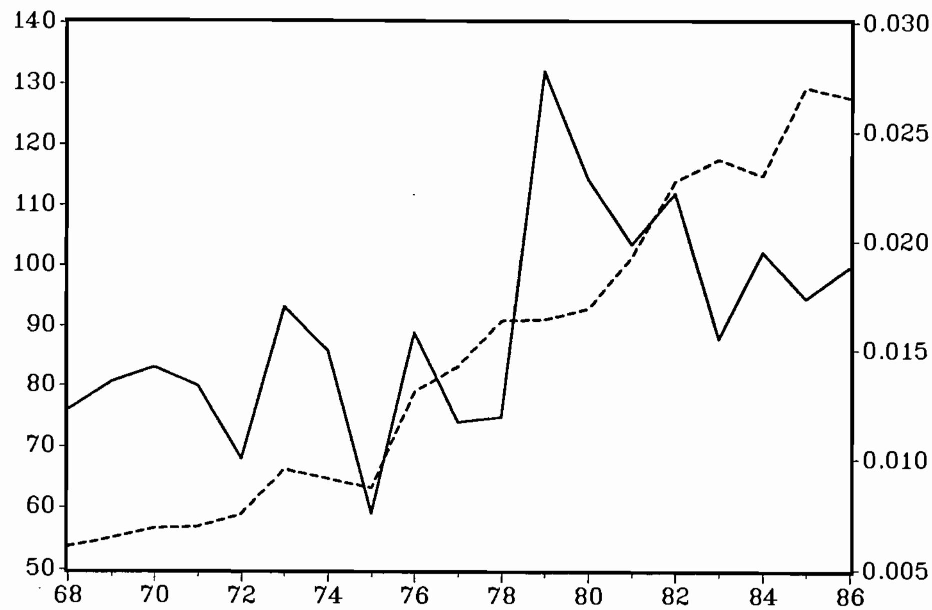


Figure 7.5 Scatter plot of **P** against **CI**

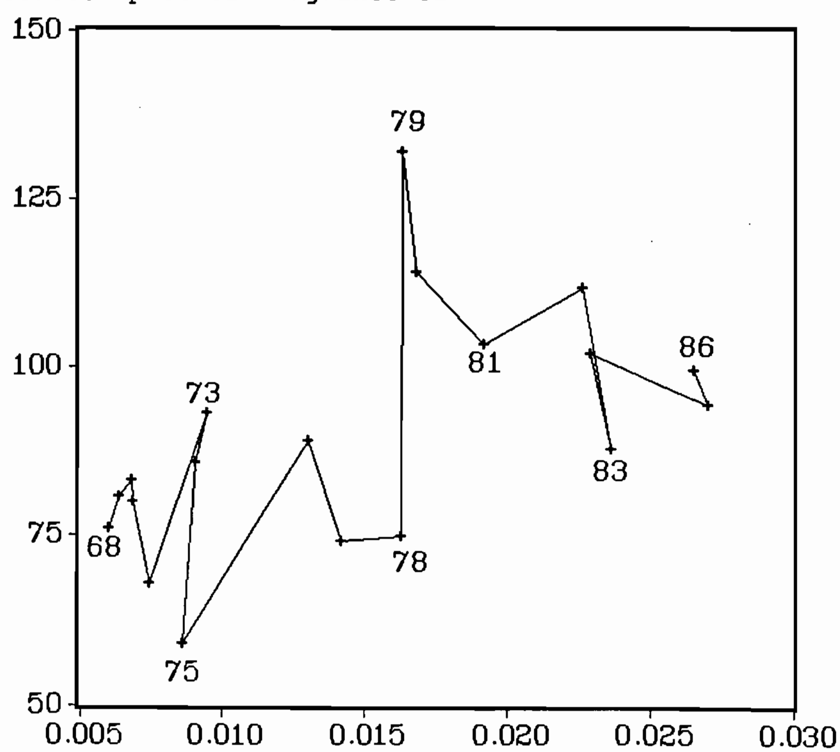


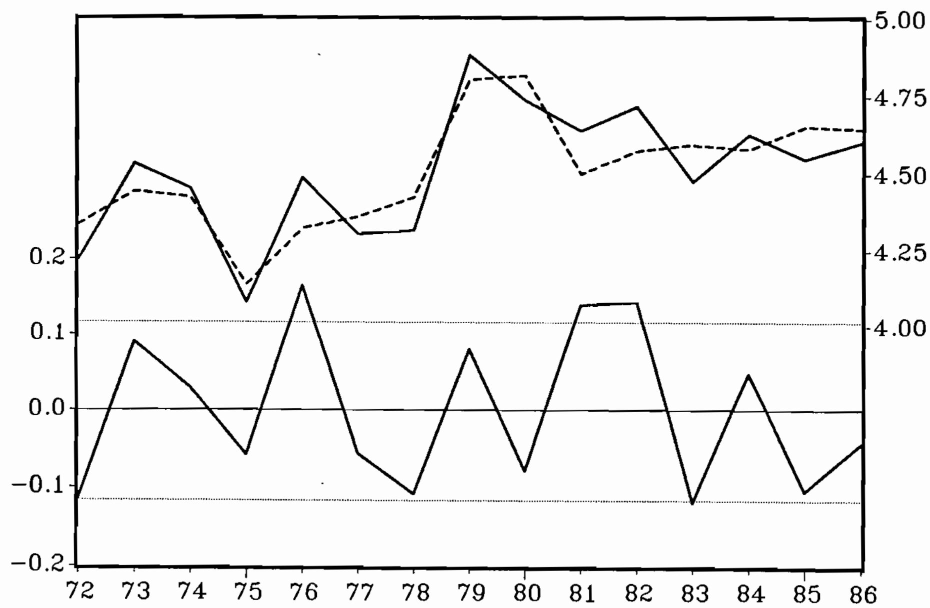
Figure 7.6 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1972 - 1986
Number of observations: 15

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	6.2899770	0.4194650	14.995239	0.000
LN (CI)	0.4533767	0.1045899	4.3348017	0.001
D7274	0.2652150	0.1103045	2.4043895	0.035
D7980	0.3776478	0.0910142	4.1493269	0.002

R-squared	0.762673	Mean of dependent var	4.507307
Adjusted R-squared	0.697947	S.D. of dependent var	0.212310
S.E. of regression	0.116684	Sum of squared resid	0.149767
Durbin-Watson stat	2.583118	F-statistic	11.78317
Log likelihood	13.26636		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 7.7-7.9: **West Malaysia - Hardwood Sawtimber:** Relationship between net delivered price (**P**) in 1980 RNG/m^3 and cut-inventory ratio (**CI**)

Figure 7.7 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

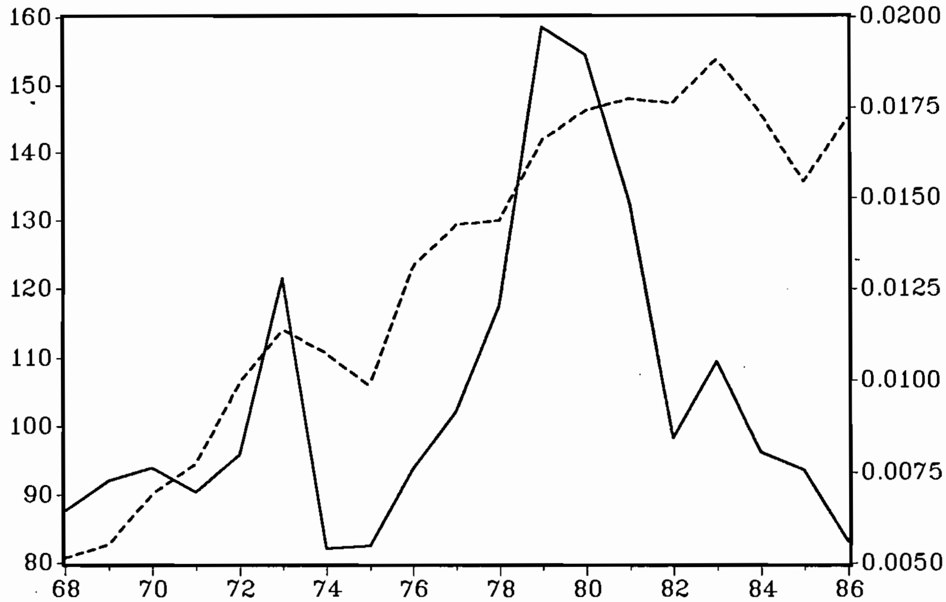


Figure 7.8 Scatter plot of **P** against **CI**

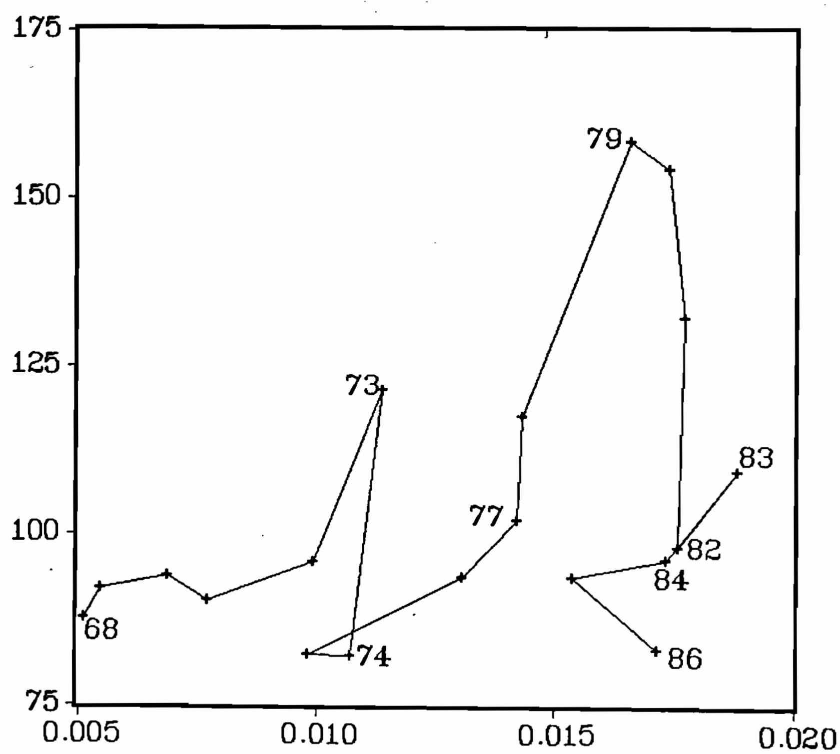


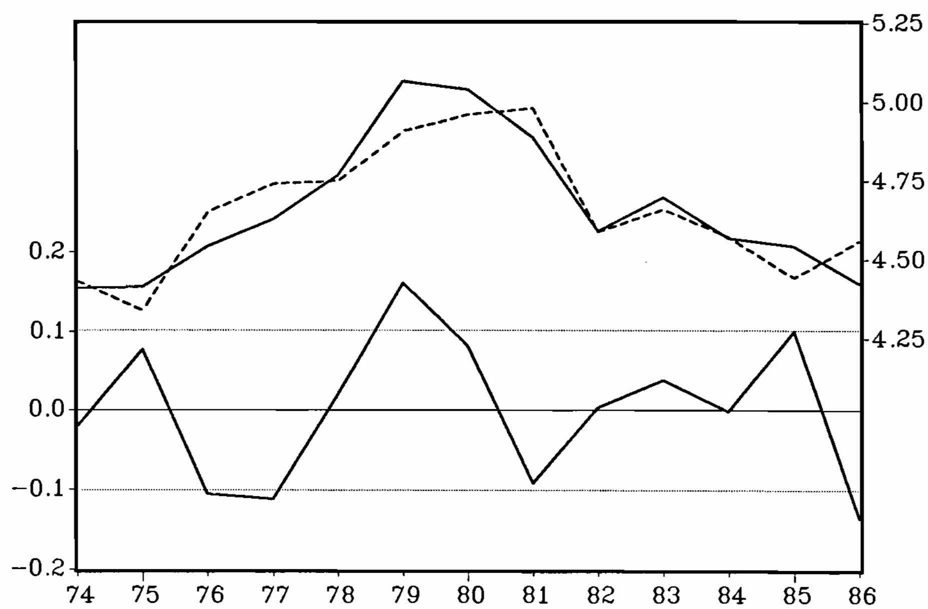
Figure 7.9 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1974 - 1986
Number of observations: 13

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	9.3873348	0.7256913	12.935714	0.000
LN (CI)	1.0932671	0.1696985	6.4424077	0.000
D8286	-0.3866658	0.0677190	-5.7098568	0.000

R-squared	0.830227	Mean of dependent var	4.657614
Adjusted R-squared	0.796272	S.D. of dependent var	0.223552
S.E. of regression	0.100903	Sum of squared resid	0.101814
Durbin-Watson stat	1.921090	F-statistic	24.45101
Log likelihood	13.07593		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 7.10-7.12: **Papua New Guinea - Hardwood Sawtimber:** Relationship between net delivered price (**P**) in 1980 KIN/m^3 and cut-inventory ratio (**CI**)

Figure 7.10 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

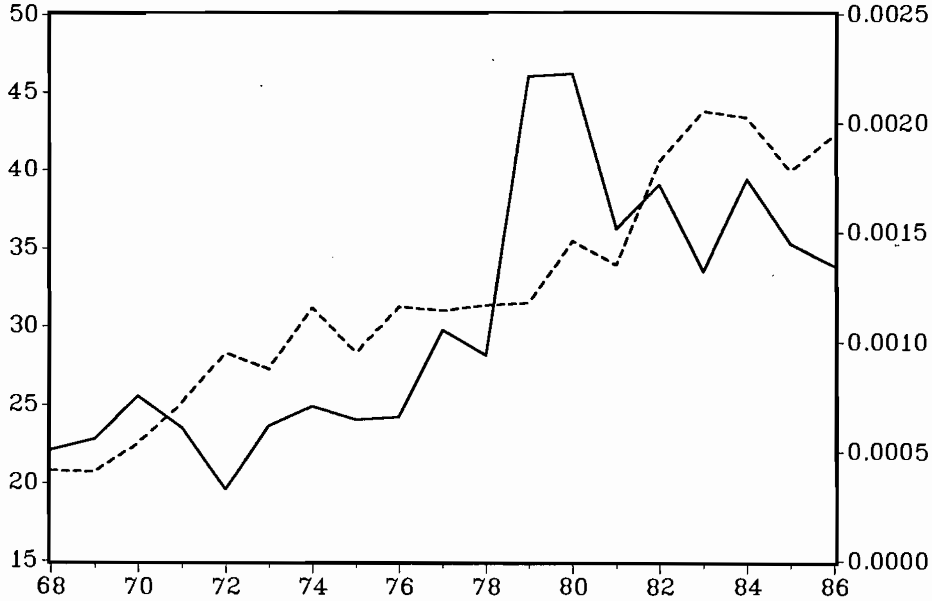


Figure 7.11 Scatter plot of **P** against **CI**

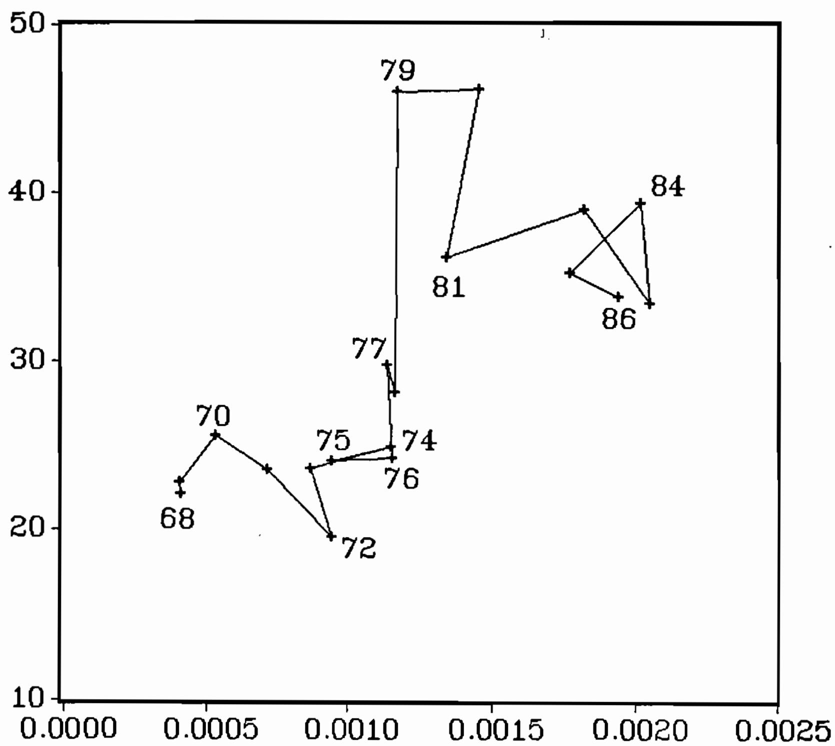


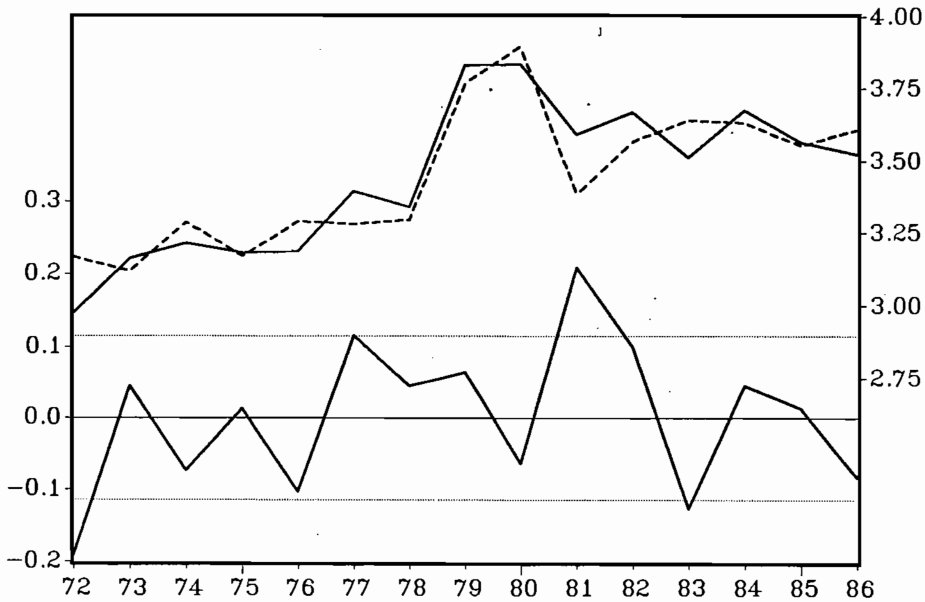
Figure 7.12 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1972 - 1986
Number of observations: 15

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7.4130878	0.6909760	10.728430	0.000
LN (CI)	0.6100455	0.1044669	5.8396041	0.000
D7980	0.4666334	0.0868668	5.3718242	0.000

R-squared	0.835106	Mean of dependent var	3.442088
Adjusted R-squared	0.807624	S.D. of dependent var	0.260577
S.E. of regression	0.114291	Sum of squared resid	0.156750
Durbin-Watson stat	2.143581	F-statistic	30.38703
Log likelihood	12.92459		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



Figures 7.13-7.15: **Philippines - Hardwood Sawtimber:** Relationship between net delivered price (**P**) in 1980 PES/m^3 and cut-inventory ratio (**CI**)

Figure 7.13 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

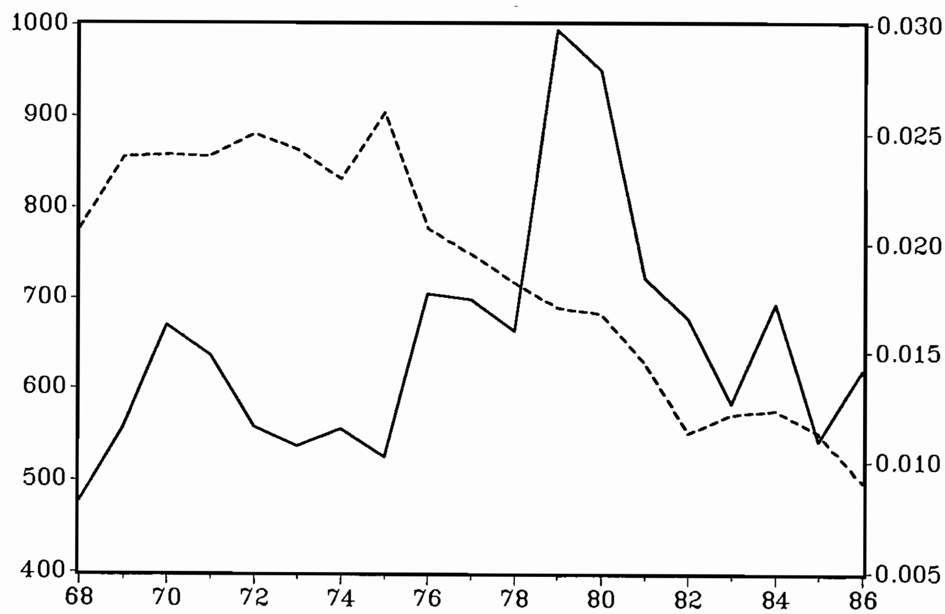


Figure 7.14 Scatter plot of **P** against **CI**

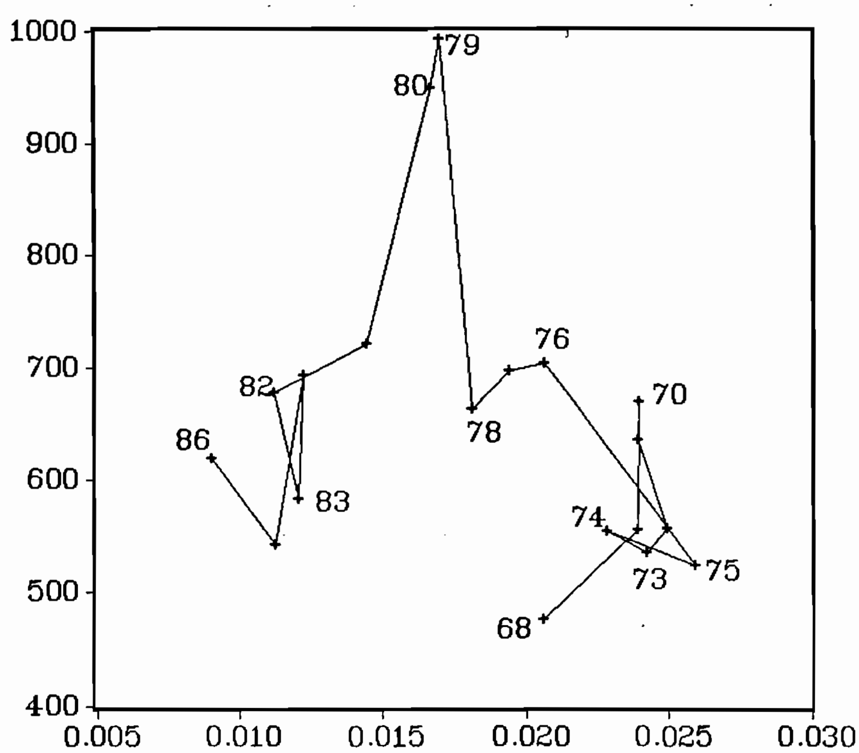


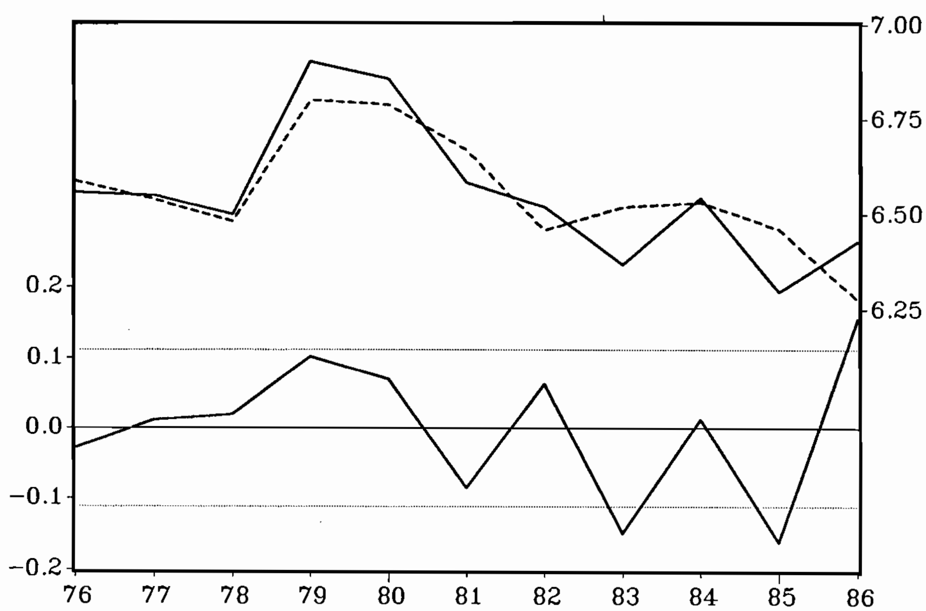
Figure 7.15 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1976 - 1986
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	10.191026	0.8429696	12.089436	0.000
LN (CI)	0.8324888	0.1931092	4.3109739	0.003
D7678	-0.3759424	0.1108834	-3.3904304	0.009

R-squared	0.700504	Mean of dependent var	6.553648
Adjusted R-squared	0.625629	S.D. of dependent var	0.182960
S.E. of regression	0.111946	Sum of squared resid	0.100254
Durbin-Watson stat	2.565546	F-statistic	9.355753
Log likelihood	10.23034		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



8. CHILE AND NEW ZEALAND

8.1 Overview

Chile and New Zealand are of critical importance to this study because they possess large supplies of softwood timber that will penetrate Pacific Rim markets over the coming decades. The volume and timing of export flows will significantly affect production, consumption, and prices in international markets. The product mix will be important because of its influence on capital investment strategies.

Chile and New Zealand provide two cases of countries that have met with tremendous success in establishing plantations of exotic species. Both countries launched aggressive programs and invested heavily in growing radiata pine in recent decades, with the strategy of exporting large volumes of wood in the future. A significant fraction of this timber is now mature, and the harvest of exotic species has nearly replaced the harvest of indigenous trees. Volumes available in the future will increase substantially. It is the rapid growth rates that have been achieved in Chile and New Zealand, rather than the amount of land devoted to plantations, that makes these countries important competitors in future forest products markets.

Statistics on the size of the forest sector reveal several key similarities between Chile and New Zealand. In 1986, the total area of forest land in Chile was 8.9 mm ha, of which 1.24 mm ha were plantations. New Zealand had 7.4 mm ha of forest land, including 1.15 mm ha of plantations. Both countries now rely on plantation timber for over 90% of their industrial wood harvest. New Zealand has a larger exotic growing stock, totaling 209 mm m^3 in 1986, compared to the Chilean exotic growing stock of 134 mm m^3 in 1986. Both countries cut approximately 9 mm m^3 of exotic wood in 1986. Available harvest projections indicate that the potential wood supply will increase more rapidly in Chile than New Zealand over the next 10-15 years.

The analysis of short-run timber supply in Chile and New Zealand requires some special considerations. First, the rapid expansion of plantations means that: 1) the use of total timber inventory is not appropriate to model timber availability; and, 2) timber qualities, prices, and markets will change as the share of plantation wood increases relative to indigenous wood. Second, the important dynamics concerning plantation growth and yield cannot be captured using simple growth-drain models. Some recognition of the age-class structure must be incorporated in the model. Third, government roles have been in flux. Policy changes have ranged from modifications in cost-sharing programs for afforestation to privatization of the resource.

Hardwood markets are small in Chile and New Zealand. We treat these exogenously in the Pacific Rim Assessment.

8.2 Chile

Although Chilean forestry is widely recognized for its plantation-based economy, only 14% of its forest land is currently in plantations. More surprisingly, these plantations contain only 13% of the growing stock. However, these plantations provide the vast majority of wood for the forest products economy. The harvest of industrial wood (fuelwood excluded) in 1987 was 12.3 mm m^3. Of this total, 91% (or 11.2 mm m^3) was radiata pine. The balance of the cut was primarily hardwoods produced from native species.

The sawlog sector in Chile is larger than the pulpwood sector. Statistics for the 1987 softwood market indicate that 6.1 mm m^3 of the cut, which amounts to 54%, was consumed in either domestic lumber production (4.8 mm m^3) or sawlog exports (1.3 mm m^3). Panels, including both plywood and reconstituted products, consumed 0.4 mm m^3. The remaining 42% was classified as pulpwood, which included 4.1 mm m^3 for domestic pulp production and 0.6 mm m^3 of pulpwood log exports. Pulpwood's share of the Chilean harvest is slightly overstated however, because the data on wood furnish include sawmill residues (this was estimated to amount to 12% in 1986). In the hardwood sector, an even higher percentage of logs are used for sawnwood: almost 70% of the 1987 hardwood cut was consumed in lumber production.

All of the data used in this section are taken from "Estadisticas Forestales," published by the INFOR (Instituto Forestal).

8.2.1 Softwood Sawtimber Supply

Softwood sawtimber harvests are the sum of softwood logs consumed at sawmills, softwood logs consumed at veneer and plywood mills, and softwood sawlogs exported. Data for softwood veneer log consumption was not published directly; rather, these data were computed by multiplying the veneer and plywood share of total panels times total softwood log consumption in panels. Although it is not likely that this procedure yields very accurate estimates, the error introduced is minimal since the total market is quite small. Softwood sawlog exports climbed from zero in 1974 to 1.0 mm m^3 in 1980. They have fluctuated considerably during the 1980s, but peaked at 1.3 mm m^3 in 1987.

The price variable (expressed in 1980 pesos/m^3) is constructed as a weighted average of sawlog prices delivered to domestic sawmills and FOB log export prices. The rationale for constructing prices in this fashion is that landowners receive income from selling logs to both markets; however, this aggregation does raise concern because sawlog export prices have been approximately three times the level of domestic prices. At this time, we do not know the extent to which these differences may be attributed to quality differences as opposed to other economic factors.

The inventory term in this model is designed to reflect the special features of this market. For forecast purposes, we incorporate the recent supply projections available from INFOR (discussed in Jelvez, Blatner, and McKetta, 1988). These projections include several scenarios. We assume that the harvest of radiata pine will double between 1987 and 2000, and thus reach 22 mm m^3. However, since these projections represent physical volumes only, or biological supply, we use these data to shift our short-run timber supply curves.

To make the model internally consistent with this methodology, we develop historical inventory numbers that provide an index of available supply. First, we assume the harvest number in 1987 is equal to the "inventory." We then backcast this "inventory" series by using the percentage changes in the actual inventory data.

Figure 8.1 depicts the real delivered sawlog price and the cut-inventory ratio from 1977 to 1987. The sample size is limited by the availability of historical price information. Real prices are quite volatile. They peaked in 1980 and have been trending upward in recent years. The cut-inventory ratio also peaked in 1979-1980, but has not demonstrated the same volatility as prices.

A scatter plot showing the relationship between harvest price and the cut-inventory ratio is shown in *Figure 8.2*. While this plot lends itself to several possible interpretations, there appears to be fairly good evidence that production follows some classical supply relationship in Chile. The graph suggests that producers are quite responsive to prices. The final equation is presented in *Figure 8.3*. The elasticity of softwood sawtimber supply with respect to the delivered log price is 2.8.

8.2.2 Softwood Pulpwood Supply

Softwood pulpwood harvests equal the sum of consumption of pulpwood logs at pulp mills, particleboard mills, and fibreboard mills, and pulpwood log exports. As noted earlier, the data are subject to some measurement error due to the inclusion of sawmill residues in the pulp numbers and the aggregation of wood for panels. Pulpwood log exports are a new phenomenon: the first exports were 0.01 mm m^3 to Italy in 1985; in 1987, 0.62 mm m^3 were exported with the majority moving to Sweden and Finland. Some pulpwood logs also are being shipped to markets in the Pacific Rim (Japan). The price variable is the real price of pulpwood logs delivered to domestic pulp mills.

The statistical analysis of these data indicated that there was no clear supply relationship for pulpwood. In light of the poor statistical results, we decided that it was most appropriate to incorporate pulpwood supply projections exogenously.

8.3 New Zealand

New Zealand plantations currently occupy about 16% of the forest land area in New Zealand. However, exotic forests now provide about 95% of the industrial wood harvest. This contrasts sharply with the 50% share provided by indigenous species in the late 1950s. The harvest of industrial wood (excluding fuelwood) in 1987 (12 months ending March 1987) was 9.1 mm m^3. Softwoods comprised approximately 97% of this volume, and exotic species comprised the vast majority of the softwoods. Exotic species other than radiata pine have been planted (primarily Douglas-fir and eucalypts), and they account for about 10% of the total planted area.

The softwood sawlog sector in New Zealand is larger than the pulpwood sector. In 1987, 5.1 mm m^3 of the softwood cut, which amounts to 57%, was consumed in either domestic lumber production and veneer and plywood production (4.7 mm m^3) or sawlog exports (0.4 mm m^3). The remaining 43% was classified as pulpwood, small logs, smallwood, and miscellaneous. In the hardwood sector, the large majority of the roundwood cut is used for pulpwood (0.24 mm m^3). This share has been increasing over time and reached about 85% in 1987.

The data used in this analysis are from "statistics of the forests and forest industries of new zealand to 1987," published by the Ministry of Forestry. While good data are available on stumpage and sawlog prices, production and harvest levels, and timber inventory and growth, it is questionable whether these data can be used to produce a useful model of short-run timber supply. First, the historical period was characterized by significant government intervention in the lumber market: lumber was subject to domestic price controls in 1965 and again from 1968 to 1979. Second and more importantly, exotic forests owned and controlled by the state have been transferred to the private sector. The new corporation is required to sell timber at a price greater than its operating cost and also to turn an annual operating profit. This represents a sharp break in past practice, so it is not at all clear that statistics on past behavior have any bearing on what to expect in the future. Below we conduct a brief exploratory analysis of the softwood sawtimber market. We have not attempted to estimate supply relationships for softwood pulpwood at this time.

Recent detailed econometric analyses of New Zealand lumber and log markets are available in Evison (1988) and Katz (1988).

Softwood Sawtimber Supply

Softwood sawtimber harvest was computed as the sum of softwood logs consumed at sawmills, softwood logs consumed at veneer and plywood mills, and softwood sawlogs exported. We examined several price variables, but focused on one -- a volume-weighted average of average stumpage prices (expressed in 1980 NZD/m^3) of exotic and indigenous timber sold by the New Zealand Forest Service.

The softwood harvest has been volatile since 1970, but the trend has been relatively flat since that time. Over this period, there has been a significant decline in real stumpage prices. A scatter plot reveals no clear pattern to the relationship between these two variables.

Expressing the quantity variable as a ratio of harvest to inventory or the area of land in timber production leads to a measure that exhibits a fairly steep decline over time. This results from the fact that most of the plantation timber is not mature so sawlog harvests have remained relatively stable in the face of substantial increases in timberland and timber growing stock. A scatter plot shows a rather well-behaved relationship between real prices and the "cut-inventory" variable; this is caused by the fact that both are declining over time. Because of the age-class dimension of the problem (and the role of government regulation), it is not reasonable to argue that prices have fallen due to a glut in timber supply. More importantly, this supply relationship would be a poor model of the future: this "apparent" supply curve suggests that real price increases are consistent only with a dramatic increase in the harvest level.

Given the uncertainty indicated by the above analysis, and the changing economics of New Zealand timber markets, we chose to use the following model of future New Zealand timber supply. We start with a biophysical representation of sawtimber supply by using the volume projections developed by Burrows, Levack, and Novis (1986). These projections imply about a 70% increase in the available volume of exotic species between 1987 and 2000, so that the harvest level in 2000 will approach 17 mm m^3 (we use the data from their reference scenario though the different planting scenarios suggest nearly identical wood flows until 2000). These rates of increase are applied directly to the recent levels of softwood sawlog supply to shift the supply curve in the future. However, rather than assume that future supply is perfectly inelastic, we assume that the elasticity is 1.0. Although the magnitude of this parameter is largely arbitrary, this modification allows some supply adjustment to reflect the fact that producers may reduce or lengthen rotation ages during good and bad markets.

Figures 8.1-8.3: **Chile - Softwood Sawtimber:** Relationship between delivered price (**P**) in 1980 PES/m^3 and cut-inventory ratio (**CI**)

Figure 8.1 Historical trends in **P** (solid line, left axis) and **CI** (dashes, right axis)

Figure 8.2 Scatter plot of **P** against **CI**

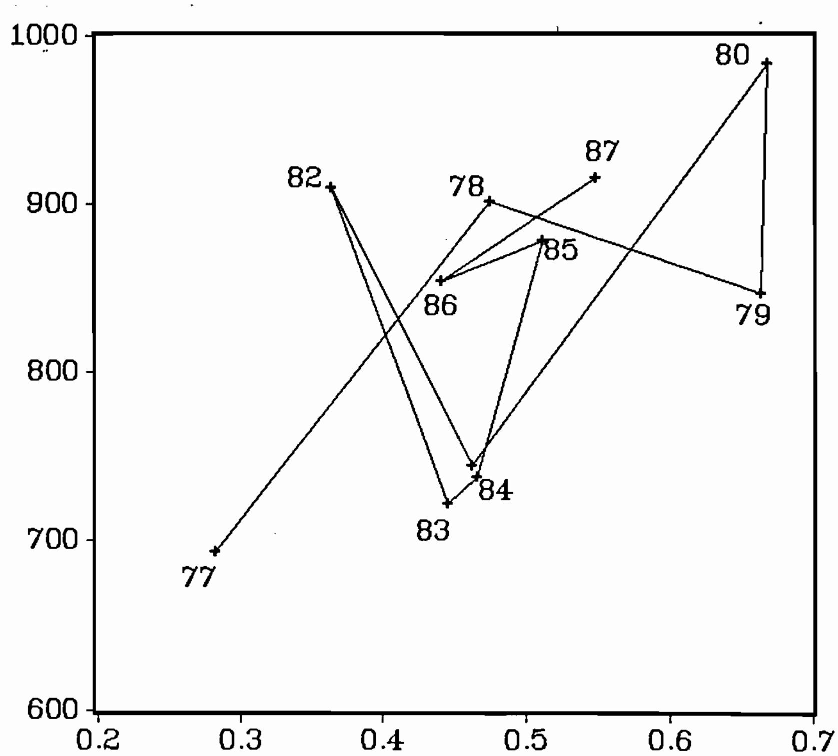


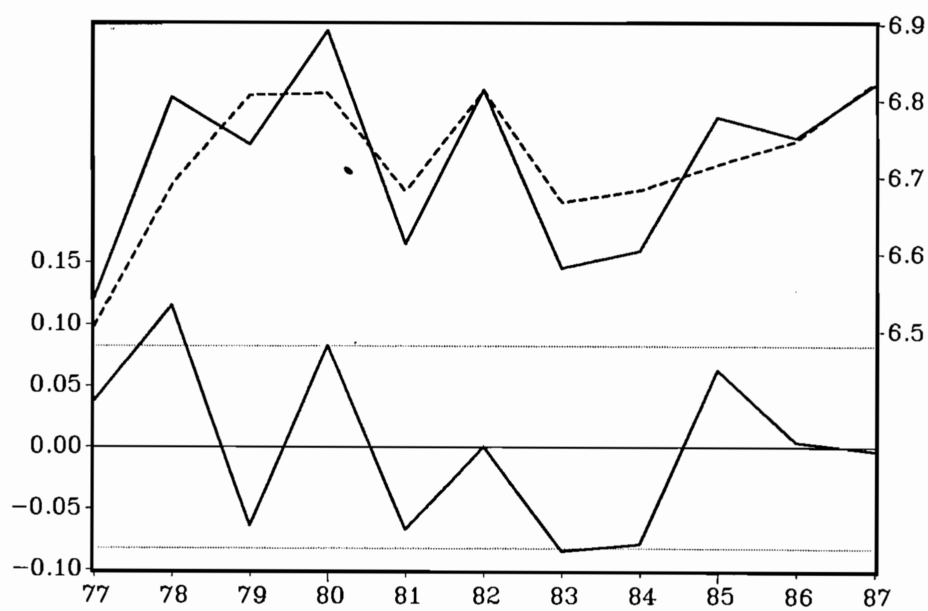
Figure 8.3 Regression results and plot of residual, actual, and fitted values

LS // Dependent Variable is LN (P)
SMPL range: 1977 - 1987
Number of observations: 11

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	6.9511232	0.0871170	79.790679	0.000
LN (CI)	0.3527103	0.1127792	3.1274422	0.017
D82	0.2174925	0.0928478	2.3424636	0.052
D8687	0.0835072	0.0651025	1.2827038	0.240

R-squared	0.651362	Mean of dependent var	6.721587
Adjusted R-squared	0.501945	S.D. of dependent var	0.116613
S.E. of regression	0.082297	Sum of squared resid	0.047410
Durbin-Watson stat	2.478719	F-statistic	4.359369
Log likelihood	14.34921		

Residual values refer to left axis; actual values (solid line) and fitted values (dashes) refer to right axis



9. KEY EXOGENOUS SUPPLY REGIONS

There are some regions that are large exporters of timber that we treat exogenously. Future timber production and exports from these regions will have a substantial impact on Pacific Rim (and world) timber markets. We have not attempted to derive econometric estimates of behavior in these regions because: 1) the supply relationships in these regions do not conform to the simple theoretical formulation that we have used in the endogenous regions; and (or), 2) the data that are necessary to model these relationships are not available.

In this section, we simply identify these regions and describe some of the key historical trends that have occurred in production and exports.

9.1 Eastern USSR

The Eastern USSR encompasses two subregions that we have examined, Eastern Siberia and the Far East. Due to the difficulty in obtaining reliable data on regional harvest levels, we have only considered trends in lumber production and log trade. Data were not available to disaggregate these trends between softwood and hardwood species. However, at the national level, data indicate that softwoods account for approximately 88% of lumber production, and 98% of lumber exports.

Figure 9.1 shows the level of lumber production for Eastern Siberia and the Far East from 1975 to 1986. It is difficult to use these data to derive regional sawlog harvest levels for two reasons. First, there is a great deal of uncertainty concerning lumber recovery rates. Data published in the FAO Yearbook suggest that the recovery rate for the USSR is well over 0.60. Based on data on maximum potential yields, existing technology, and recovery rates in other countries, we believe such estimates are unrealistically high. Second, detailed data on sawlog trade between regions are not available. However, there is enough information to suggest that sawlogs are transported long distances within the country. This is especially true in the case of shipments to European USSR, where producers are clearly facing timber supply shortages.

Although it is not possible to make accurate inferences on sawlog harvests from the lumber production data, we rely on these data to gain some insights into sawlog production trends. Aside from what appears to be cyclical reductions in lumber output in the early 1980s, there has not been much change in the levels of production between the mid-1970s and mid-1980s. If one considers a longer historical period, there is evidence of significant growth in both regions. Lumber production in Eastern Siberia was 11.6 mm m^3 in 1960, and 15.0 mm m^3 in 1970 (compared to 17.3 mm m^3 in 1975). Thus, the growth between 1960 and 1975 was 50%. The rate of growth in the Far East was smaller, but still significant. Lumber production in the Far East totaled 5.1 mm m^3 in 1960 (compared to 6.6 mm m^3 in 1975), so growth between 1960 and 1975 amounted to 30%.

Our estimates of sawlog exports from the Eastern USSR are depicted in *Figure 9.2*. Data on log exports by region of origin are not available. To develop these data, we simply aggregated the log export data by destination region. We adopted the rule that logs exported to Europe originated in Western USSR, while the source of logs exported to Japan and China was assumed to be the East.

There has been essentially no growth in sawlog exports from the Eastern USSR between the late 1970s and 1986-1987. The period of tremendous expansion in this market was the decade of the 1960s. In 1960, Japan and China (whose share was negligible) imported only 0.8 mm m^3 of sawlogs. By 1970 this volume had climbed to 5.9 mm m^3. Perhaps the most significant change during the 1975-1987 period was the shift in shares between Japan and China. China imported only 0.2 mm m^3 of sawlogs from the USSR in 1975, compared to 2.3 mm m^3 in 1987 (which amounted to 31% of Eastern USSR exports).

Exports of roundwood pulpwood logs from the Eastern USSR are shown in *Figure 9.3*. The export volumes are quite small relative to sawlogs; however, there has been significant growth since 1975. As with sawlogs, China also has become an important destination for pulpwood logs. In 1986 and 1987, China received 29% of the pulpwood logs exported from the Eastern USSR. The changing mix of sawlog and pulpwood log exports may signal a reduction in the quality of logs available from the Eastern USSR. Of course, there could be many other factors that explain this shift.

9.2 Western USSR

By our definition, the Western USSR is comprised of two subregions, the European region of the USSR and Western Siberia. Due to its vast supply of timber and proximity to consuming markets, the European region has historically produced substantially more timber than the other three subregions of the USSR.

Lumber production is shown by subregion in *Figure 9.4.* The most salient feature of this graph is the dramatic reduction in lumber production in the European region. Furthermore, it is likely that this trend understates the decrease in sawlog harvests in this region due to the shipment of logs from Western Siberia to European USSR. Hence, it would also be true that the increase in sawlog harvests in Western Siberia (as reflected by the lumber production trend) would be understated. Between 1960 and 1975, the long-term trend in European lumber production had been stable.

Figure 9.5 presents estimates of sawlog exports from the Western USSR. The log trade data are constructed in the manner described in Section 9.1. Most of the exports have been destined to Eastern Europe and Finland, although Sweden has become a large market in recent years. Export levels have been quite erratic during the 1975 to 1987 period. The volume of exports has been relatively small.

Exports of roundwood pulpwood logs from the Western USSR are shown in *Figure 9.6.* The relative mix of pulpwood and sawlog exports from the Western USSR is almost the opposite of what we observed in the Eastern USSR. Although growth in pulpwood exports was quite rapid in the 1960s, export levels were quite stable from 1975 to 1986, before showing a surge in 1987. Finland generally receives about half of this volume (although its share declined in 1987), while Sweden, East Germany, Italy, Austria, Hungary, and Norway also are large markets.

9.3 West Africa

West Africa is the remaining region that deserves special attention. Historically, this region has exported a substantial volume of hardwood sawlogs and veneer logs. In the last decade, there has been a significant shift in its export position.

Hardwood sawlog and veneer log production is plotted in *Figure 9.7*, along with log exports. Production levels rose sharply from the early 1960s to 1973 and then plummeted in the 1974-1975 recession. Production climbed to a new peak in 1980, and subsequently stabilized in the 1980s. The log export peak during this period occurred in 1973: export volumes registered 8.2 mm m^3, which was 53% of sawlog production. Log exports have fallen sharply since 1973 and totaled only 3.8 mm m^3 in 1986 (only 24% of regional production). Most of the sawlogs diverted from export have been used to produce lumber that has been consumed within the region.

Figure 9.1: **Eastern USSR - Sawnwood:** Historical production trends in Eastern Siberia (solid line, left axis) and the Far East (dashes, right axis) in million m^3

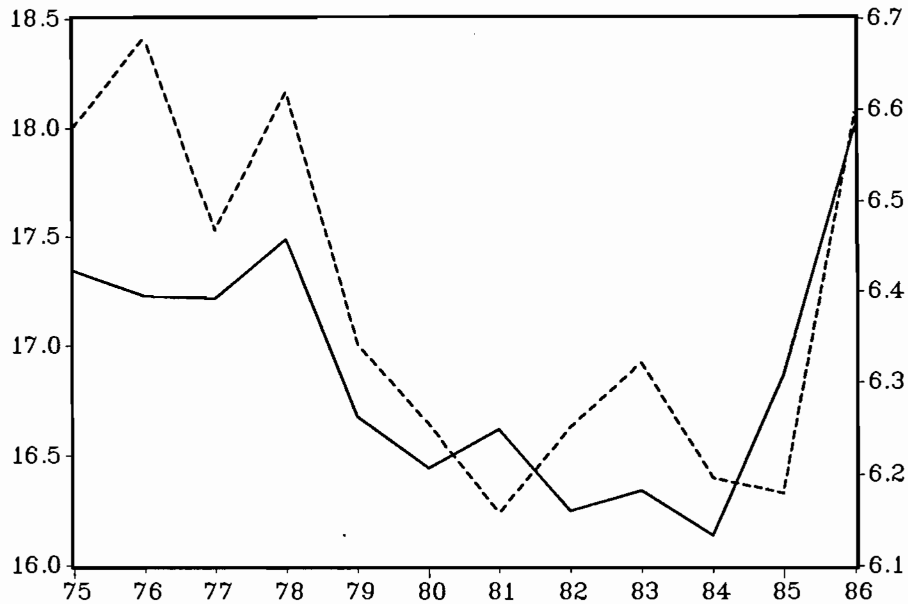


Figure 9.2: **Eastern USSR - Sawlog Exports:** Historical trend in million m^3

Figure 9.3: **Eastern USSR - Roundwood Pulpwood Exports:** Historical trend in million m^3

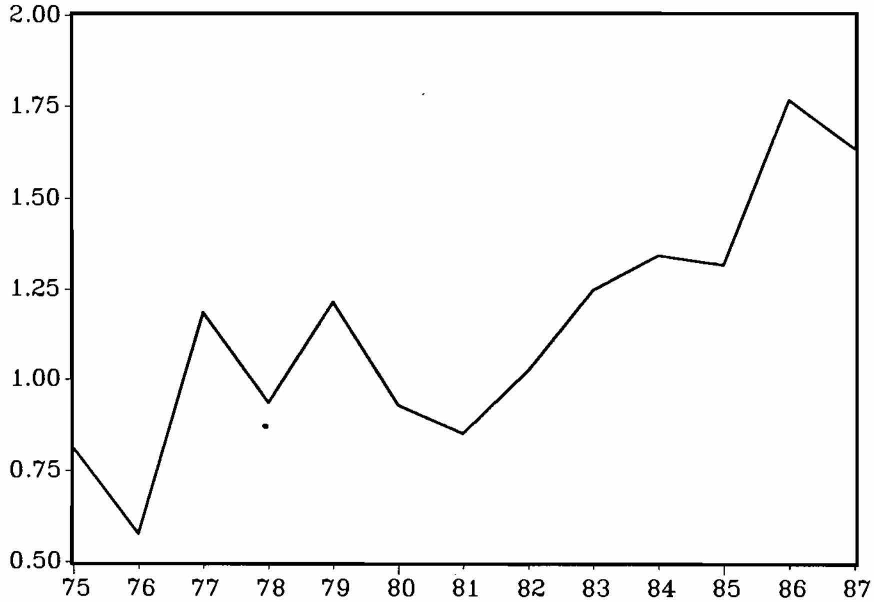


Figure 9.4: **Western USSR - Sawnwood:** Historical production trends in the European region (solid line, left axis) and Western Siberia (dashes, right axis) in million m^3

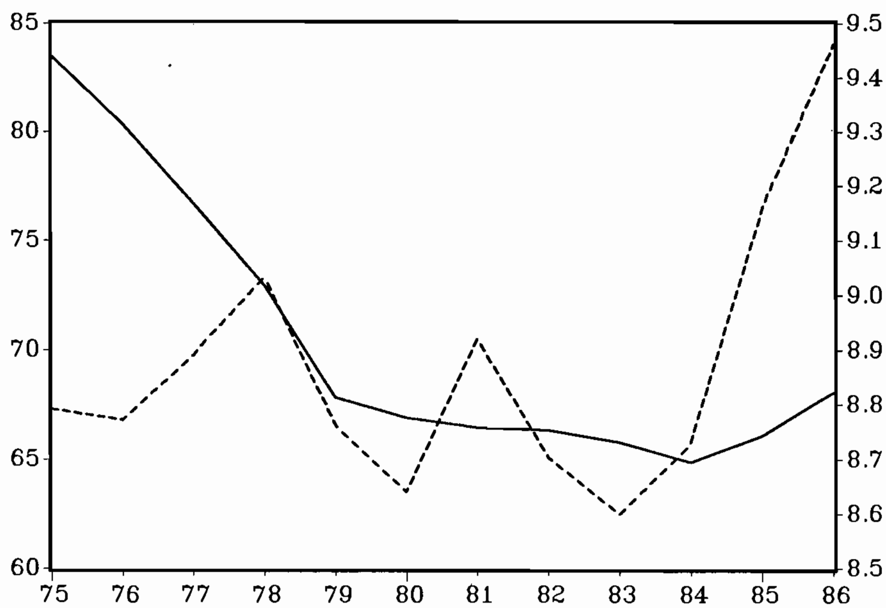
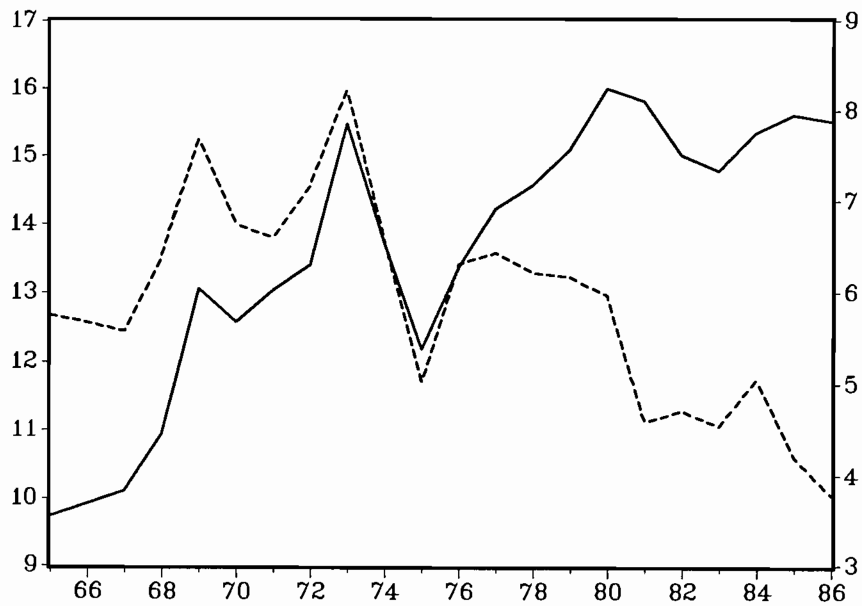


Figure 9.5: **Western USSR - Sawlog Exports:** Historical trend in million m^3

Figure 9.6: **Western USSR - Roundwood Pulpwood Exports:** Historical trend in million m^3

Figure 9.7: **West Africa - Hardwood Sawlogs and Veneer Logs**: Historical trends in production (solid line, left axis) and exports (dashes, right axis) in million m^3



10. SUMMARY OF RESULTS

This section provides a brief summary of the results of the analysis of short-run timber supply. *Table 10.1* provides data on softwood sawtimber, and data on hardwood sawtimber are presented in *Table 10.2*. All data represent estimates as of 1986, since some of the data for 1987 are not available, and often the numbers are preliminary. We show 43 regions, instead of the 40 listed in Section 1.2, because private and public ownerships in the U.S. West are shown as separate regions.

Sawtimber production (or harvest/removals) is shown in the second column of each table. This definition of sawlogs and veneer logs is the same as that used by FAO: it is equivalent to the volume of logs consumed in sawmills, logs consumed in veneer and plywood mills, and logs exported for these uses. Our estimate of world softwood sawtimber production in 1986 is 714 mm m^3, which is reasonably close to FAO's estimate of 695 mm m^3. However, there are some major discrepancies among the regional numbers. Our estimate for the USSR is 39 mm m^3 higher than FAO, for the U.S. our estimate exceeds FAO by 5 mm m^3, and for Canada we report 25 mm m^3 less production than FAO. We also show higher production levels for hardwood sawtimber: 280 mm m^3 compared to FAO's estimate of 264 mm m^3. Unlike the large offsetting differences that we observe for softwoods, the world hardwood numbers differ because we consistently show higher production across regions. The only notable discrepancy is for the U.S. where our estimate exceeds FAO's by almost 9 mm m^3 (or 24%). The other significant differences (in mm m^3) are: USSR (+3), Indonesia (+3), Malaysia (+1), and Canada (+1).

The inventory numbers are included in *Tables 10.1* and *10.2* to provide some insight into the size and potential importance of each region. Inventory represents the entire growing stock volume (as opposed to sawtimber only). Although a great deal of work was involved in developing some of these numbers, they should be interpreted cautiously. For some regions, the actual year of the inventory may not be 1986, but may be the reported estimate in 1985 (or 1984). For other regions, the data may be based on simple extrapolation of inventory data from previous years. We do not report inventory numbers for several regions because they were not used in the statistical estimation of timber supply, or because they will not be directly used in CGTM.

The cut-inventory ratio (multiplied by 100) is shown in the fourth column of these tables. Expressed in this fashion, the data indicate the percent of the 1986 inventory that was harvested in that year. Note that these percentages refer to the amount of sawtimber that is cut, and exclude the roundwood pulpwood volumes. The numbers tend to be higher for softwoods, particularly in the U.S. The hardwood cut-inventory ratios appear relatively low in the major producing regions, with the notable exceptions of the Malaysian regions.

Price levels are shown in 1980 USD/m^3 in columns 5-7. These are included to demonstrate two important features of sawlog markets: 1) the relative shares of stumpage and harvest and delivery costs in the delivered log price; and, 2) the relative level of delivered sawlog prices among the regions.

In the final two columns, the elasticity of sawtimber supply is shown with respect to the stumpage price and delivered sawlog price. The elasticities are not affected by the exchange rate; thus, they are identical with respect to local currencies and U.S. dollars. The elasticities are computed at the 1986 values. The year obviously has no affect on the supply elasticities for constant-elasticity functions. However, in most regions, sawlog supply elasticities are comprised of two components: stumpage, and harvest and delivery. If harvest and delivery costs are treated as exogenous (hence perfectly elastic), the sawlog elasticity is equal to the stumpage elasticity divided by the stumpage share of delivered sawlog cost. In these cases the elasticities will change over time as a function of the stumpage share. The Southeast Asian regions constitute exceptions to this procedure. In these five regions, the elasticities apply to net delivered prices rather than stumpage (see footnote to *Table 10.2*). If the government fee is exogenous, then we determine the supply elasticity with respect to the delivered price by dividing the computed elasticity by the harvest and delivery share of total costs.

There is a wide range of variation in both stumpage supply elasticities and delivered sawlog price elasticities. Softwood sawlog supply elasticities range from 0.3 in Japan to 5.8 in the U.S. North. Hardwood sawlog supply elasticities range from 0.4 in Japan to 3.9 in the U.S. South. We make no attempt here to rationalize the differences among regions. These differences provide a useful starting point for discussions concerning short-run timber supply and for future analysis in this area.

Finally, there are two comparisons between these results and previous research that are important. First, the inclusion of nonzero price elasticities for public timber supply in the U.S. West is a relatively new approach to modeling public behavior. This will change the character of model simulation results, particularly over the course of business cycles. In the past, most studies simply assumed that public timber supplies were exogenous. A more in-depth analysis of public supply behavior is provided in Adams, Binkley, and Cardellichio (1988). Second, these elasticities are significantly higher than those used in the simulations reported by the IIASA Forest Sector Project (see Kallio, Dykstra, and Binkley, 1987). Assuming all else equal, simulations using these elasticities in the CGTM will reduce the rate of price inflation from that determined in the IIASA project.

Table 10.1 **Softwood Sawtimber:** Production (Q), inventory (I), and cut-inventory ratio (expressed in percent); stumpage price (STMP), harvest & delivery cost (H&D), and delivered sawlog price (DELP); supply elasticity with respect to stumpage price and delivered sawlog price

REGION[b]	Q	I[a]	Q/I	STMP	H&D	DELP	ELASTICITY	
	(mm m^3)		%	(1980 USD/m^3)			STMP	DELP
U.S.:								
PNWW,PV	43.87	859	5.1	18.4	22.0	40.4	0.7	1.6
PNWW,PB	22.97	1791	1.3	18.4	22.0	40.4	1.3	2.8
PNWE,PV	4.94	232	2.1	17.3	20.0	37.3	1.1	2.3
PNWE,PB	9.40	861	1.1	17.3	20.0	37.3	0.9	1.8
INL,PV	13.24	787	1.7	8.8	24.0	32.8	0.8	3.0
INL,PB	19.85	2963	0.7	8.8	24.0	32.8	0.5	1.8
ALASKA[c]	1.73					71.4		
CA,REDWOOD	7.98	226	3.5			45.0		
SOUTH	77.68	2531	3.1	20.5	9.6	30.1	0.7	1.0
NORTH	10.49	1010	1.0	9.6	17.3	26.9	2.1	5.8
CANADA:								
BC,COAST	18.80	3428	0.6			30.5		3.2
INTERIOR	47.95	7546	0.6			17.6		1.1
EAST	34.50	6240	0.6			23.6		1.4
C. AMERICA	5.10							
S. AMERICA:								
BRAZIL	21.30							
REST,NO	0.06							
CHILE	4.72					14.4		2.8
REST,SO	0.43							
EUROPE:								
FINLAND	16.39	1460	1.1	29.9	10.7	40.6	2.9	3.9
SWEDEN[d]	22.14	2203	1.0	40.2	4.1	44.3	0.4	0.5
REST,WEST	56.30	3889	1.5	49.3	10.7	60.0	1.0	1.2
REST,EAST	23.90					60.8		
ASIA:								
JAPAN	16.18	1781	0.9	88.4	76.0	164.4	0.3	0.3
SO. KOREA	0.65	117	0.6			67.1		
INDONESIA	0.35							
E MALAY+	0							
W MALAY+	0							
PNG	0.06							
PHILIP	0.04							
CHINA+	33.07					73.5		
TAIWAN+	0.30					130.7		
INDOCHINA	0.25							
INDIA+	2.79							
MIDEAST	3.89							

Table 10.1 **Softwood Sawtimber** (continued)

REGION	Q (mm m^3)	I (mm m^3)	Q/I %	STMP (1980 USD/m^3)	H&D (1980 USD/m^3)	DELP (1980 USD/m^3)	ELASTICITY STMP	ELASTICITY DELP
USSR[e]:								
WEST	135.60							
EAST	43.04							
AFRICA:								
NORTH	0.12					119.7		
EAST	0.86							
SOUTH	3.87					139.6		
WEST	0							
OCEANIA:								
AUSTRALIA	3.49							
NEW ZEAL.	5.79			10.5	12.5	23.0	1.0	2.2
OTHER	0.04							

Notes:
a) Inventory refers to the total growing stock, not just sawtimber.
b) For specific regional definitions, refer to Section 1 or the appropriate individual sections. The key difference between the regions listed here and those shown in Section 1 is that the above U.S. West regions are subdivided between private (PV) and public (PB) ownerships.
c) The production number for Alaska represents only log exports.
d) For Sweden, the price reported under STMP is actually the price delivered roadside. The reported stumpage elasticity represents the supply elasticity with respect to the roadside price.
e) USSR production is allocated on the basis of total lumber production.

Table 10.2 **Hardwood Sawtimber**: Production (Q), inventory (I), and cut-inventory ratio (expressed in percent); stumpage price (STMP), harvest & delivery cost (H&D), and delivered sawlog price (DELP); supply elasticity with respect to stumpage price and delivered sawlog price

	Q	I[a]	Q/I	STMP	H&D	DELP	ELASTICITY	
REGION[b]	(mm m^3)		%		(USD/m^3)		STMP	DELP
U.S:								
PNWW,PV	3.88	200	1.9			35.0		
PNWW,PB	0	92						
PNWE,PV	0	2.8						
PNWE,PB	0	2.8						
INL,PV	0	112						
INL,PB	0	131						
ALASKA	0							
CA,REDWOOD	0							
SOUTH	22.08	3325	0.7	9.4	13.0	22.4	1.7	3.9
NORTH	20.05	3042	0.7	22.5	11.0	33.5	0.7	1.1
CANADA:								
BC,COAST	0.22	23	1.0			35.0		
INTERIOR	0.80	1882	0.04			25.0		
EAST	4.50	2880	0.16			30.0		
C. AMERICA	1.77							
S. AMERICA:								
BRAZIL	18.68							
REST,NO	6.41							
CHILE	0.60					14.4		
REST,SO	4.44							
EUROPE:								
FINLAND	1.45	339	0.4	36.7	11.1	47.7	0.9	1.1
SWEDEN	0.39	400	0.1	33.8	4.3	38.1		
REST,WEST	22.26	3219	0.7	84.3	11.1	95.4	1.0	1.1
REST,EAST	12.59					88.5		
ASIA:								
JAPAN	2.62	1079	0.2			199.5		0.4
SO. KOREA	0.38	70	0.5			54.6		
INDONESIA[c]	27.38	4905	0.6	3.5	60.0	63.5	0.9	0.9
E MALAY+[c]	21.28	863	2.5	9.5	43.7	53.2	2.2	2.7
W MALAY+[c]	8.59	500	1.7	7.0	36.5	43.5	0.9	1.1
PNG[c]	1.50	860	0.2	1.6	45.2	46.8	1.6	1.7
PHILIP[c]	3.20	354	0.9	1.3	79.4	80.7	1.2	1.2
CHINA+	21.02					62.8		
TAIWAN+	0.20					52.5		
INDOCHINA	5.52							
INDIA+	17.97							
MIDEAST	1.20							

Table 10.2 **Hardwood Sawtimber** (continued)

REGION	Q (mm m^3)	I (mm m^3)	Q/I %	STMP (1980 USD/m^3)	H&D (1980 USD/m^3)	DELP (1980 USD/m^3)	ELASTICITY STMP	ELASTICITY DELP
USSR[e]:								
WEST	19.37							
EAST	6.15							
AFRICA:								
NORTH	0.10					128.4		
EAST	1.27							
SOUTH	0.58							
WEST	15.51					88.8		
OCEANIA:								
AUSTRALIA	5.27							
NEW ZEAL.	0.04			10.5	12.5	23.0		
OTHER	0.68					57.3		

Notes: a,b,e) See corresponding footnotes in *Table 10.1*.

c) For the Southeast Asian regions, the price reported under STMP is the government fee assessed on timber that is extracted. However, the elasticity that is reported in the stumpage column represents the elasticity of hardwood sawtimber supply with respect to the net delivered price.

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