Analysis of Policy Reforms in the New Zealand Forest Manufacturing Sector

by

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Abstract

New Zealand experienced dramatic restructuring programs after the Labor party won the national elections in 1984. Deregulation of price controls, removal of the log export ban, and privatization of public assets were the main shocks to the forest sector. The purpose of this paper is to analyze the impacts of these reforms on wood and paper industry cost, production, and cost efficiency. Unlike previous work, the effects of privatization and deregulation are compared to determine which shock had the most influence on the forest sector. Results show that production decreased, total cost increased, and cost efficiency decreased after deregulation for the sector, and that deregulation was more significant than privatization for the wood and paper sectors. In particular, removal of the log export ban had the greatest impact, while privatization had little effect on industry production and cost. This suggests that countries with comparative advantages in wood processing who implement deregulation or privatization may suffer through a short term period of lower cost efficiency as the economy adjusts to higher input costs in those sectors. In New Zealand's case, the adjustments most likely affecting efficiency have been investments in new technologies, which require time to attain maximum efficiency. The results are contrary to other studies that have predicted increased efficiency as a result of privatization.

Dedication

I dedicate this work to my father, Donald (1936-1969), who died before completing his dissertation and my mother, Ann (1938-1986), who did not live long enough to see any of my accomplishments.

Acknowledgments

I want to give thanks to several people and institutions that have helped me complete this arduous and awakening task. First, I would like to thank my doctoral committee Chairman, Greg Amacher, for having the patience and strength of character to put up with my many mistakes and sloppy attempts at becoming an economist. His extraordinary ability as a mentor helped me see light when darkness and despair threatened to consume me. Second, I would like to thank my other committee members Hugh Bigsby, Richard Cothren, Jay Sullivan, and Harold Wisdom for their patience, insightful comments, and positive contribution to my training. Third, I thank David Klemperer for helping out during my defense. In addition, I would like to thank William R. Bentley for giving me opportunities to discover my new path in life. His gentle nudges and bits of wisdom were instrumental in developing my desire to return to graduate school a second time.

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Table of Contents

Page Numbers

List of figures

Page Numbers

List of tables

Page Numbers

List of appendices

Page Numbers

Chapter appendices

Dissertation appendices

Chapter 1

Introductory Remarks

Objectives

The focus of this dissertation is to analyze the impacts of reform policies on the New Zealand forest sector. The three policy reforms analyzed are removal of price controls, removal of the log export ban, and privatization. The removal of price controls occurred economy wide in 1984 which also coincided with the election of the Labour Government and start of dramatic structural reform of the economy. The removal of the log export ban occurred in 1987 simultaneously with the dismantling of the New Zealand Forest Service and corporatization of its remaining physical resources. The last policy reform, privatization, began in 1990 with the sale of forest management rights and mills to domestic and international producers. This chapter focuses on four areas: New Zealand's history with deregulation and privatization, available and existing literature on policy reform, conceptual models, and an outline of each dissertation chapter.

Historical Background

Prior to the 1984 national election, New Zealand had a highly regulated small open economy with a socialistic governmental structure. During the 1950s and 1960s, it was claimed that New Zealand had the highest standard of living among developed

nations. In addition, unemployment was low, prompting a then prime minister to claim that he could name each unemployed person on the fingers of one hand. However, this began to change with the first oil crisis in 1973. Annual inflation rose to an average 14% and remained that way until 1982 were an extensive wage-price freeze program was enacted (Colin, 1989).

In 1972, Great Britain joined the European Economic Union. Britain had been the leading importer of primary goods such as wool and mutton from New Zealand. New Zealand still had a preferential status in terms of trade with Britain, but this would decrease over time. This erosion of status had a psychological impact on New Zealanders born before World War II. They considered Britain home, but those born after WWII felt differently and spawned a greater desire for a separate nationhood (Colin, 1992).

After 1972, New Zealand's economy began to erode under the weight of supporting too many social programs while experiencing reduced trade with Great Britain. This led to high inflationary conditions prior to the 1984 elections. Conditions became so bad that net public debt in New Zealand was 40% of GDP, the current account balance was over -8% of GDP, unemployment was less than 6%, and net public debt was 40% of GDP (Evans et al., 1996). According to Evans et al. (1996), New Zealand lost their AAA credit rating on sovereign external debt. In addition, Prime Minister Muldoon's administration attempted to control rising interest rates. Farming subsidies reached a high of NZ $352 million, and manufacturing export tax incentives were around NZ $700 million (Colin, 1989).

The national elections in 1984 resulted in the defeat of Muldoon's National party and the rise in power of Lange's Labour party. This new administration implemented an economic restructuring program of deregulation and privatization to remedy the growing economic crisis. This restructuring was an unexpected event by the nation at large (Colin, 1989; The Economist, 1996). The programs resulted in the removal of financial controls, a floating exchange rate, tax reform, removal of subsidies, liberalization of the labor market, commercialization of state enterprises, privatization of state enterprises to reduce budget deficits, and trade reform resulting in the removal of export incentives and import licensing (Colin, 1989). Deregulatory events that occurred immediately in 1984 included the elimination of subsidies, an end of wage and price restrictions, phasing out of import licensing requirements, removal of controls on outward investment and borrowing, deregulation of foreign exchange rate, removal of interest rate controls, elimination of export credit guarantees, and currency devaluation (Duncan and Bollard, 1992).

Since the implementation of these policy events, many benefits have accrued. According to Evans et al. (1996), the real growth of GDP has approached 3-6%, and the current account balance has decreased to an approximate 4% deficit of GDP. In addition, the consumer price index remains less than 4%, and net public debt is less than 40%. Although unemployment increased to more than 10% in 1992, by 1995 it had decreased to roughly 6%. Government fiscal balances continue to have surpluses ranging between 0.75% to 3.5%. Trade liberalization has also allowed the expansion of imported consumption goods.

Corporatization was implemented to make government agencies to operate as profit maximizing businesses. There were massive layoffs that increased temporary unemployment from 3% to 11% within a few years. When the NZ Forest Service was corporatized, employment roles fell from 7070 to 2652 staff members. Capital restructuring increased as agencies tried to upgrade which placed an additional stress on the governmental budget.

Privatization of state assets has helped improve the governments overall balance sheet (Duncan and Bollard, 1992). The aim was to sell off government assets to help alleviate public debt. Of the corporatized government agencies, five experienced some level of privatization. These enterprises included the Forestry Corporation, Work Services, Rural Bank, Petrocorp and the Shipping Corp. Only the Forestry Corporation was completely eliminated in 1997.[1a] When the Forestry Corporation was privatized, full rights to public forest plantations were not sold off. Only long-term management or cutting rights were sold for 30 to 40 year periods. The reason for this method of privatization was that the government had not settled Maori (native peoples) land claims. Therefore in this study, privatization is viewed as a transfer of inputs to the private sector. In addition, the Forestry Corporation was still responsible for long-term wood contracts with Tasman Corporation. These were settled in 1996.

Given the historical conditions of New Zealand's national economy, I would like to narrow the focus and review the country's forest sector response to policy reforms. Like in North America, New Zealand has historically experienced rapid clearing of

native vegetation for homesteads, in many cases at the expense of the native population that had settled 800 years previously. Given New Zealand's small size (roughly the size of either the United Kingdom or Japan), many believed early on that there was a threat of running out of merchantable wood resources. Thus in 1919, the New Zealand Forest Service was commissioned to prevent a timber famine from occurring.

The New Zealand Forest Service was involved in many aspects of the forest sector. Early on it experimented with exotic tree species to find the most appropriate for establishment in the New Zealand growing conditions. Radiata pine, a native of Monterey California, was selected to be the primary species for reforestation. Reforestation on state land and incentives for planting on private lands led to a production forest area base of 1.1 million acres, of which 47.3% was owned by the national government in 1989 which represented a significant portion of the state's portfolio of assets (Bilek and Horgan, 1992). In addition, the state was the largest owner of natural forests. Also, the NZ Forest Service was involved in utilization and processing side of the industry. The government's involvement lead to the creation of the Prolog Industries Ltd. which manufactured sawn timber, wood chips, treated round products, and related produce (Duncan and Bollard, 1992). Through these investments the government became the dominant player in the New Zealand forest sector.

[1a] e.g., see Duncan and Bollard (1992) for an overview of the impacts of the privatization programs.

The New Zealand Forest Service had a variety of issues to contend with prior to the 1984 national elections and subsequent deregulation programs.[1b] First, the agency had a multiple-use mandate, which required consideration of both commercial wood production and environmental benefits, such as recreation and stewardship of native forests in its planning decisions. Second, the agency was required to compensate for unemployment by increased hiring of unskilled labor (Birchfield and Grant, 1993). Third, the agency was heavily involved in incentive programs to promote reforestation on private lands, and, finally, the agency faced a system of price controls that artificially lowered the price of domestic wood relative to world prices. Other pressures on the agency included a ban of log exports and increasing public opposition to harvesting of native forests.

Prior to reforms, the New Zealand forest manufacturing sector comprised of two major subsectors: the solid wood and paper processing sector. The wood industry was comprised of 100s of small sawmills dependent on public timber and various panel mills. The sawmills were widely scattered across the countryside. The paper industry was composed of fewer mills that were largely located on the North Island. The paper industry felt that the gains from greater economies of scale outweighed the transportation costs of hauling wood fiber long distances (Neilson and Smith, 1994).

In 1984, soon after the National election, price controls on state wood were removed. The intent of this reform was to allow prices on state wood to rise to world

[1b] Besides the broad implementation of deregulation programs, the New Zealand forest sector saw removal of incentives, timber concessions and state wood prices increase to world levels (Birchfield and Grant,

levels. Higher wood prices would lead to greater input costs from raw materials necessary for production in the solid wood and paper industries. Other policies such as incentives for reforestation and concessions for cutting on timberlands were removed. Reforms were also implemented on the rail industry to reduce transportation costs. This had particular importance to the paper industry which was largely located in the North Island and transported fiber from long distances. It was claimed that gains from economies of scale off-set long distance hauling costs (Neilson and Smith, 1994). In addition, the NZ dollar was devalued by 20% making all exports commodities cheaper.

In 1987, log export bans were removed and the NZ Forest Services was dismantled and corporatized into the Forestry Corporation. At this time all natural forests were transferred to a newly created government agency called the Department of Conservation. This agency severely restricted timber harvesting on its land. The Forestry Corporation controlled all remaining resources such as tree plantations and mills. The log export ban provided an opportunity for New Zealand forest owners to sell their logs to foreign buyers because of the better prices offered compared to domestic producers. According to Birchfield and Grant (1993), the corporation went from a deficit of NZ $71 million in the previous year to a surplus of NZ $63 million. In addition the staff members in the organization fell from over 7070 persons in 1987 to 2597 in 1990 (Duncan and Bollard, 1992). In addition, the New Zealand economy was experiencing a policy reduced recession from the vast array of economic reforms (Dalziel and Lattimore, 1996).

1993).

In 1989, the Corporation announced its intentions of selling off all state commercial forest assets and began privatization operations in 1990. In 1990, it sold off almost half of its forest land assets (Brown and Valentine, 1994). In 1992, further sales reduced the government's ownership to 17.5% (Turland, 1990) of pre-reform area. The remainder was preserved until 1996 to uphold long term contracts signed before reform programs.[1c] In 1996, the government bought its way out of the contract responsibilities. In 1997, remnants of the Forestry Corporation were sold leaving the government's involvement in plantation forestry to areas held by Timberlands West Coast.

Conditions prior to 1990 motivated privatization of New Zealand state-owned assets. The New Zealand government was interested in reducing national debt and wanted to privatize government agencies across the board. Domination of the forest sector by the Forest Service promoted concern over diversifying the ownership structure of the industry. In addition, capital investment was low, preventing the production base from competing in international markets (Boer, 1990).

The perceived benefits from privatization efforts after 1990 were numerous. From 1990 to 1995, total roundwood removals from New Zealand forests increased from 11.7 million m^3 in 1990 to 16.4 m^3 in 1995, a 40% increase. Exports of all forestry products increased from NZ$ 1.4 billion to NZ$ 2.6 billion in 1995, a 89% increase. In addition, investment in fixed capital assets increased from NZ$ 542 million to NZ$ 557 million. Investment in the wood processing industry increased from 253 rough sawmills

[1c] An interesting note is that because of potential Maori land claims, privatization was essentially the selling of all cutting rights for one rotation or roughly 30 to 40 years.

in 1990 to 379 in 1995, a 50% increase. In addition, the ownership structure changed from 52% state ownership in 1989 to 14.7% in 1995 (NEFD, 1995).

The problem that this dissertation is attempting to analyze is whether deregulation and privatization had a positive or negative impact on the New Zealand forest manufacturing sector. The hope is that the surprise implementation of these reforms will provide some indicator to how production and cost changed as the economy adjusted to fewer controls and greater competition from the international market.

Literature Review

Before conducting the analysis in this study, the literature concerning deregulation and privatization was reviewed. Rigorous analysis of deregulation and privatization are scarce in the forestry literature but have been conducted separately for several other industries.[1d] In the U.S., two sectors that have experienced deregulation are the airline industry in the 1970s and telecommunications industry in the 1980s.[1e] Not surprisingly, there are numerous papers that address these reforms. One study by Bruning (1991) attempted to examine the relative efficiency of different airlines and determine whether evidence of deregulation or liberalization led to substantial improvements in efficiency. Another study by Graham et al. (1983) showed that immediately after the Airline Deregulation Act of 1978, competition generally increased but was not always strong enough to eliminate price increases. Work by Moore (1986)

[1d] See Greenhut et al. (1991); Kyle et al. (1992); Whinston and Collins (1992).
[1e] See Hunt and Lynk (1991); Taylor and Taylor (1993); and Hausman et al. (1993).

examined the impacts of deregulation and found further supporting evidence for many of the aims of deregulation programs. He showed evidence that competition increased after deregulation. However, later studies by Borenstein (1989) and Evans and Kessides (1991) showed that competition decreased as large firms began to dominate at particular airports and routes. Other studies of deregulation in the airline industry focused on the impact of reforms on cost efficiency (Bruning, 1991; Ehrlich et al. 1994).

The telecommunications industry also studied the impacts of deregulation. As with the airline industry, the primary aim for deregulation was improving competition and efficiency (Kaestner and Kahn, 1990). Kaestner and Kahn studied the effects of regulation and competition on AT&T. They used a classical oligopoly model with econometric methodologies to estimate the impacts of regulatory changes and deregulation. Their results suggest that deregulation improved efficiency, but increased competition did not lower prices as expected. For example, they found AT&T did not lower prices in competitive areas, and this contributed to reduced market share and a non-dominant position.

Privatization has also been a popular research topic within the general economics literature. Since the early 1980s privatization programs have been implemented throughout the world, from the America's, the United Kingdom, Mexico, Chile, Japan, New Zealand, and most recently Eastern Europe (Karscig, 1990; Lüders, 1991; Haskel and Szymanski, 1993). The basic reasons supporting privatization reforms were to increase profitability, increase operating efficiency, increase firm capital investment,

increase output, and alleviate federal budgetary deficits (Megginson et al. 1994; Bilek and Horgan, 1992).

The debate over privatization has contributed to a debate about the merits of state ownership versus private ownership. The difference between the two ownership types is the management objective and mechanism for enforcing compliance of these objectives. In the case of state ownership, managers seek to maximize a social welfare function whose objective is broad based (Laffont and Tirole, 1991). If the manager does not adhere to this maximization plan, there is no mechanism for forcing compliance. Thus, in many instances, government agencies may become bloated with unskilled labor as a mechanism for absorbing excess unemployment (Birchfield and Grant, 1993). In the case of private ownership, managers seek to maximize profit. Shareholder pressure provides an incentive for the private firm manager to adhere to this objective function (Laffont and Tirole, 1991; Vickers and Yarrow, 1991).

Current research on the benefits between state versus private ownership shows mixed results. Megginson et al. (1994) used a Wilcoxan signed ranking approach that showed strong performance improvements for profit, increased efficiency, and increased capital investment for full and partial privatization. Ehrlich et al. (1994) finds that state ownership lowered long-run productivity. Boardman and Vining (1989), who review the literature prior to 1990, present different studies that show increases and decreases to long-run productivity with public ownership. They argue that six studies support the claim that state-owned enterprises are more efficient than private firms, sixteen studies

indicate no difference between ownership categories, while thirty two studies support the notion that private firms are more efficient than state-owned enterprises.

Another issue important in privatization programs is whether competition has a greater impact than private ownership of state agencies on efficiency. An empirical study by Vining and Boardman (1992) claims that previous evidence supporting the notion that competition has a greater impact on efficiency than ownership does not hold. They show, using Canadian data from 500 non-financial corporations, that ownership has a greater impact from an efficiency perspective.

Considering the importance of changes to efficiency after deregulation and privatization, a review of efficiency measures was necessary. There are several techniques for measuring efficiency, many of these focus on technical efficiency. Technical efficiency is defined as producing the maximal amount of output per given set of inputs. It is also defined as the distance of output production to the production possibility frontier. Another measure, allocative efficiency, is defined as the distance from the production possibility frontier to the iso-cost curve. The two main models for measuring these types of efficiency are the deterministic and stochastic approaches.

The deterministic approach assumes that output is bounded from above by a non-stochastic production possibility frontier. The advantage of this approach is that distribution assumptions are not necessary. Technical efficiency is simply measured as before as the distance of the output from the production possibility frontier. In addition, price data is not required. However, results are sensitive to outliers.

Stochastic frontier models are assumed to be bounded from above by a stochastic production possibility frontier. The advantage of this model is that it considers random noise in data. In addition, this approach can be used for estimating efficiency measures by specifying cost and profit frontiers. Cost frontiers can estimate the cost efficiency of an industry or firm while profit frontiers can estimate profit efficiency for the same groups. The disadvantage is that a distribution assumption is necessary, however, econometric tests can provide evidence supporting the most appropriate functional form for fitting the data.

Conceptual Models

From the literature review it was apparent that there was not one way to analyze the impacts of deregulation and privatization. Several of the studies indicated that efficiency changes and changes in input prices were key concerns. The purpose of presenting the conceptual models used in this dissertation is to provide a theoretical basis that links the chapters together. There are two conceptual models in this dissertation. The first deals with price changes and their impacts on market demand and supply. The second model discusses the impacts of policy reforms on efficiency in the wood processing industry.

Conceptual Model One

The first model is concerned with analyzing the impacts of changing input prices on the New Zealand forest manufacturing sector. Input prices were primarily affected by

deregulation of stumpage prices and railroad fees after the 1984 national election.

Stumpage prices were held to artificially low levels and transportation prices were high.

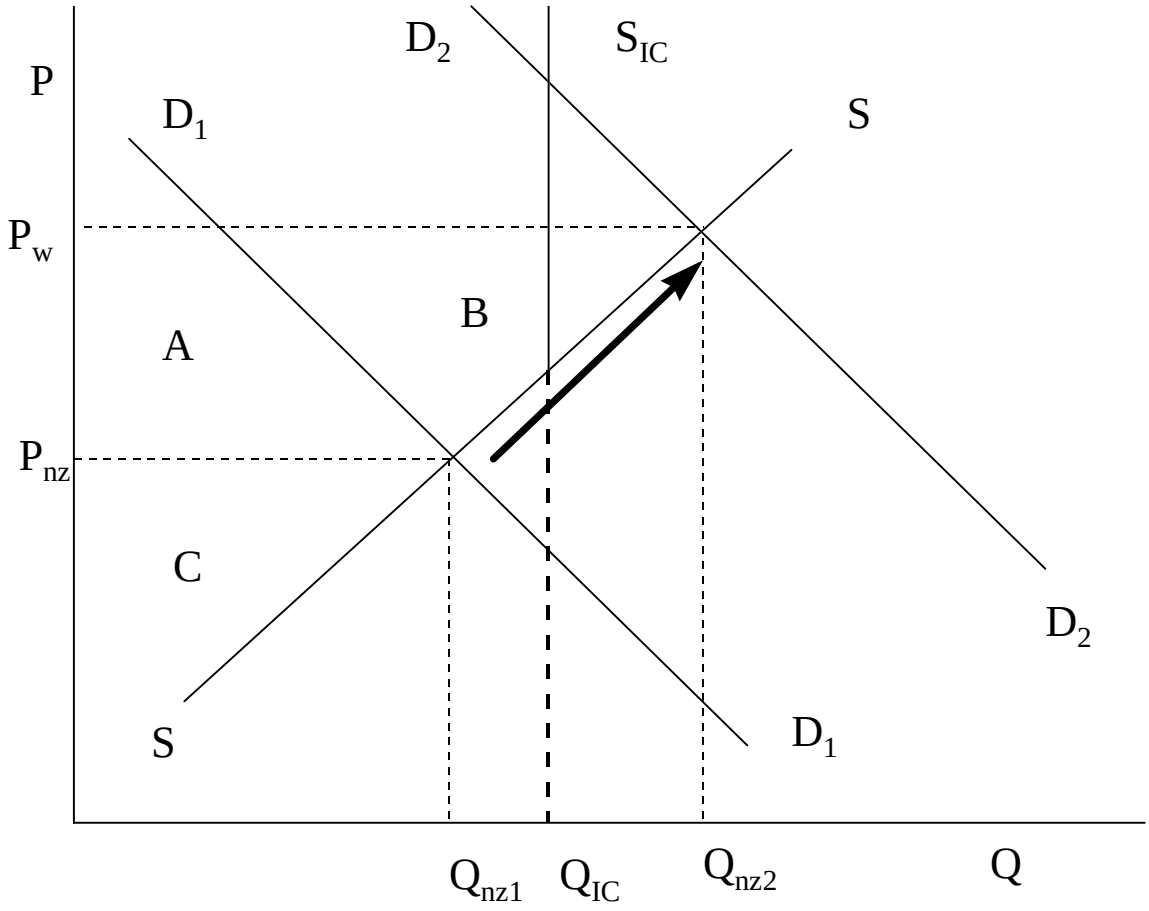

Figure 1A: Timber Market After Deregulation of Price Controls

where,

Q_{nz1}, Q_{nz2} Q_{IC}	Equilibrium quantities
P_w, P_{nz}	World price, New Zealand price
SS	Supply function
D_1D_1, D_2D_2	Demand functions
A+B	Producer surplus gains

For the wood industry, the expectation is that the price of New Zealand stumpage would rise to world levels. This would motivate suppliers of stumpage to produce more timber resulting in a movement up the aggregate timber supply curve. The higher prices for stumpage would result in a producer surplus and create welfare gains for timberland owners. The producer surplus is the sum of areas A, B, and C in Figure 1A. The timber market supply curve is constrained by limited forest area and inventory of mature timber. The demand curve shifts out due to market clearing, but it does not shift all the way to Q_{nz2} because of the kink in the supply curve. There is evidence that stumpage prices increased after the removal of this price control, however, roundwood removals did not consistently increase until after the removal of the log export ban in 1987.

The other reform that occurred when stumpage price controls were removed was the deregulation of the railway industry. Transportation prices were artificially high. The expectation is that lower transportation prices would act like a lower stumpage price, creating a shift in supply of wood fiber (Figure 1B). This would stimulate an outward shift of the paper industry's aggregate supply function because paper processors hauled fiber long distances to supply their mills.

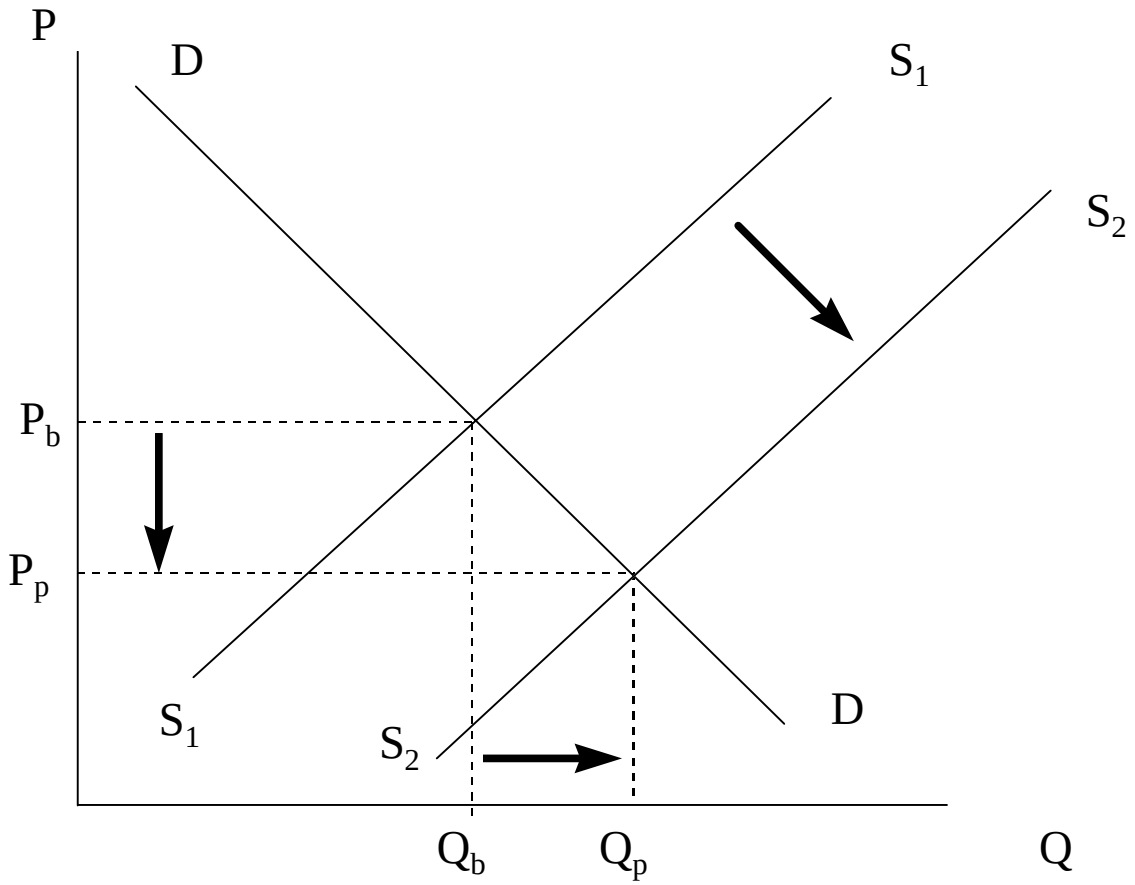

Figure 1B: Paper Industry View of Stumpage Market After Deregulation of Railways

where,

S_1S_1, S_2S_2	Supply function
DD	Demand function
P_b, P_p	Equilibrium prices
Q_b, Q_p	Equilibrium quantities

During the restructuring of New Zealand's economy, interest rates were higher than the world level which reduced investment from domestic sources. Financial reforms relaxed international capital controls and allowed the free entry of foreign direct investment in 1985, leading to increased investment in the private sector. Dalziel and Lattimore (1996) show that while investment was decreasing in the public sector after

reforms, investment in the private sector was increasing. It is expected that high interest rates and removal of capital controls will result in an inflow of foreign capital into the New Zealand forest manufacturing sector. It is also expected that when enough capital entered the New Zealand economy, interest rates would fall to world levels. Analysis of long-term interest rate support this notion. Interest rates were high during the 1980s and have subsequently dropped off in the 1990s (Figure 1C).

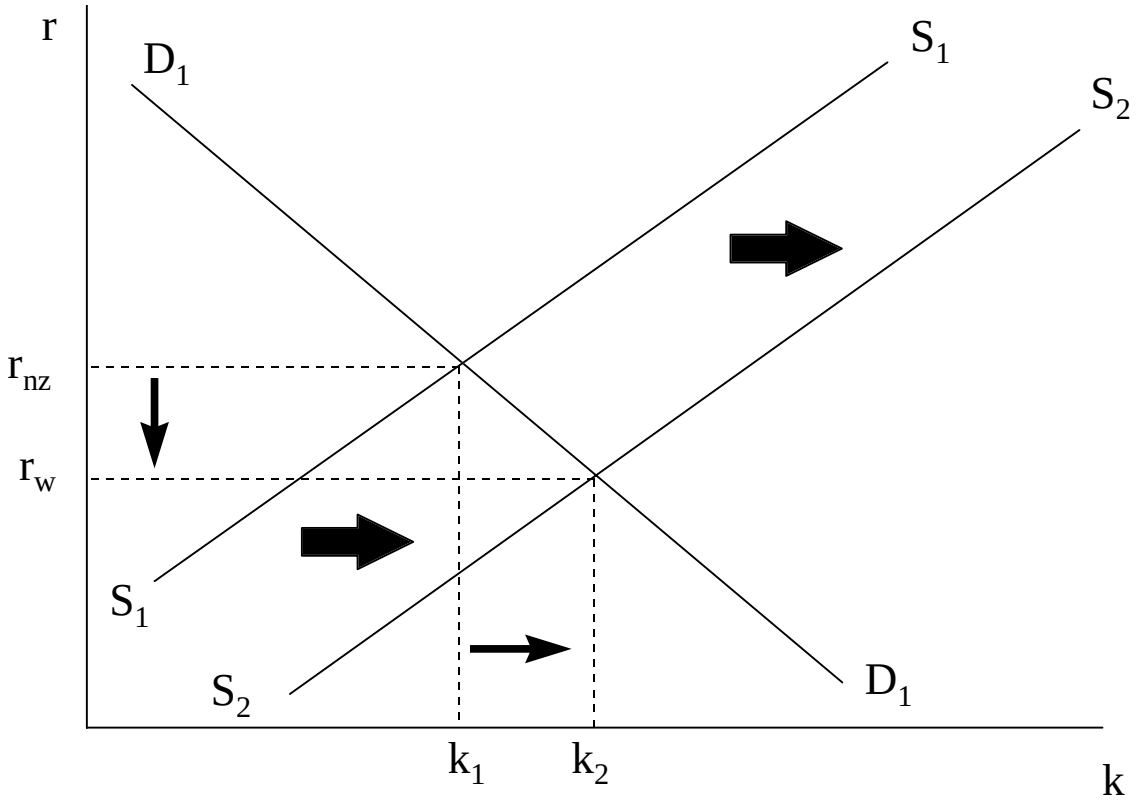

Figure 1C: Capital Inflow into the New Zealand Capital Market.

where,

S_1S_1, S_2S_2 Supply curves

D_1D_1	Demand curve
r_{nz}	New Zealand interest rate
r_w	World interest rate
k_1, k_2	Equilibrium capital

When the New Zealand Forest Service was corporatized, the log export ban on public timber was removed. This allowed the NZ Forestry Corporation to sell their wood to international buyers. This action was motivated by their mandate to operate as a profit maximizing firm. Prior to this reform the private sector could sell logs to international buyers at world prices. Assuming that logs from both the private and public sectors were perfect substitutes, the export of logs from public forest plantations would increase input prices for wood in the NZ forest manufacturing sector. The price of private logs is assumed to not change. Since the New Zealand Forestry Corporation was the largest tree plantation owner, they would receive a producer surplus and welfare gains as indicated in Figure 1A. It is expected that the increased export of raw material would create an input constraint that would affect production in both the wood and paper processing industries by shifting down each industry's aggregate production function (Figure 1D).

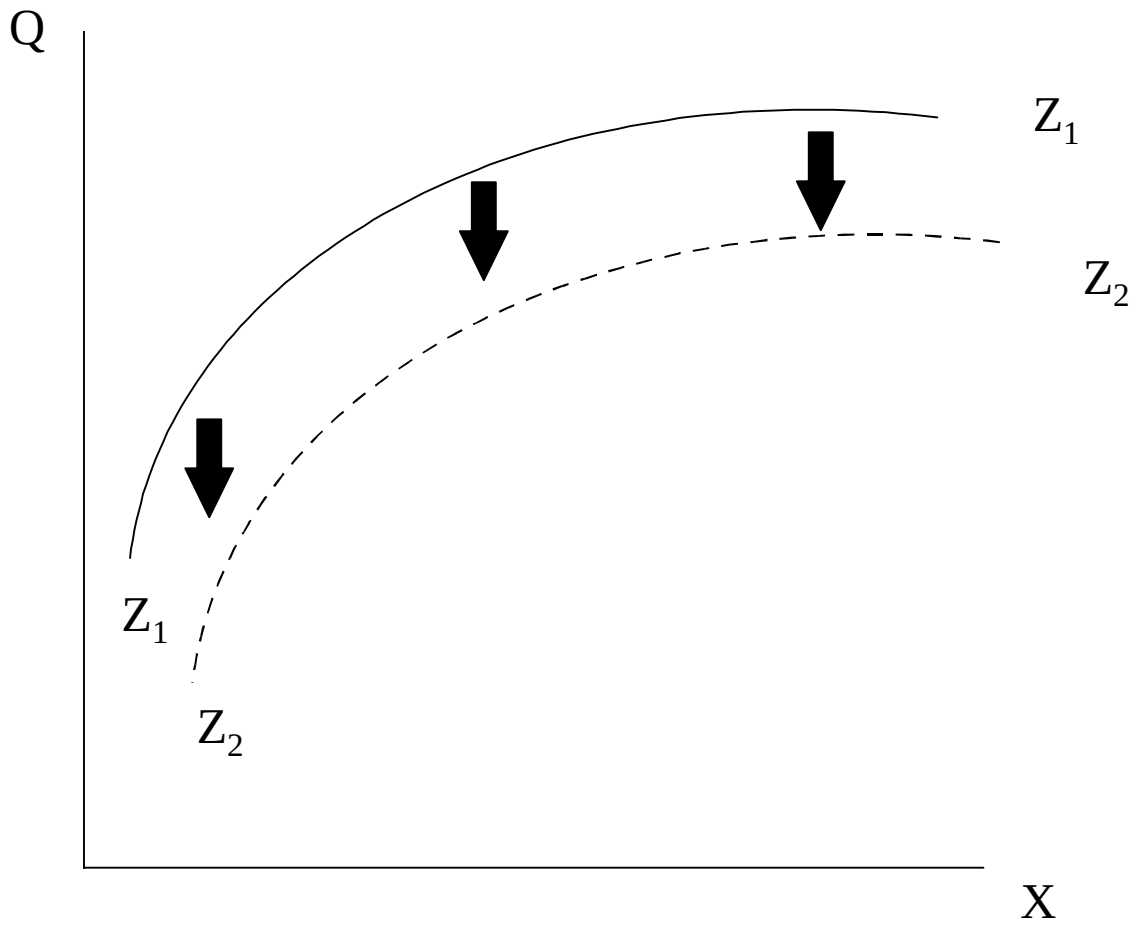

Figure 1D: Aggregate Production Function

where,

Q	Output quantity
X	Input
Z_1Z_1, Z_2Z_2	Production functions

The combination of high interest rates, higher input prices, and raw material constraints lead to short-term cost inefficiencies. Cost efficiency is defined as a given level of output being produced at the lowest expense. It is expected that the

inefficiencies caused by the oversupply of capital, international competition for raw material, and the industry's inability to expand fast enough led to a kink in the marginal cost function for both the wood and paper industries. At this kink, producing one more unit of output would cost an infinite amount. An example of this would be cutting immature timber to meet mill raw material needs (Figure 1E).

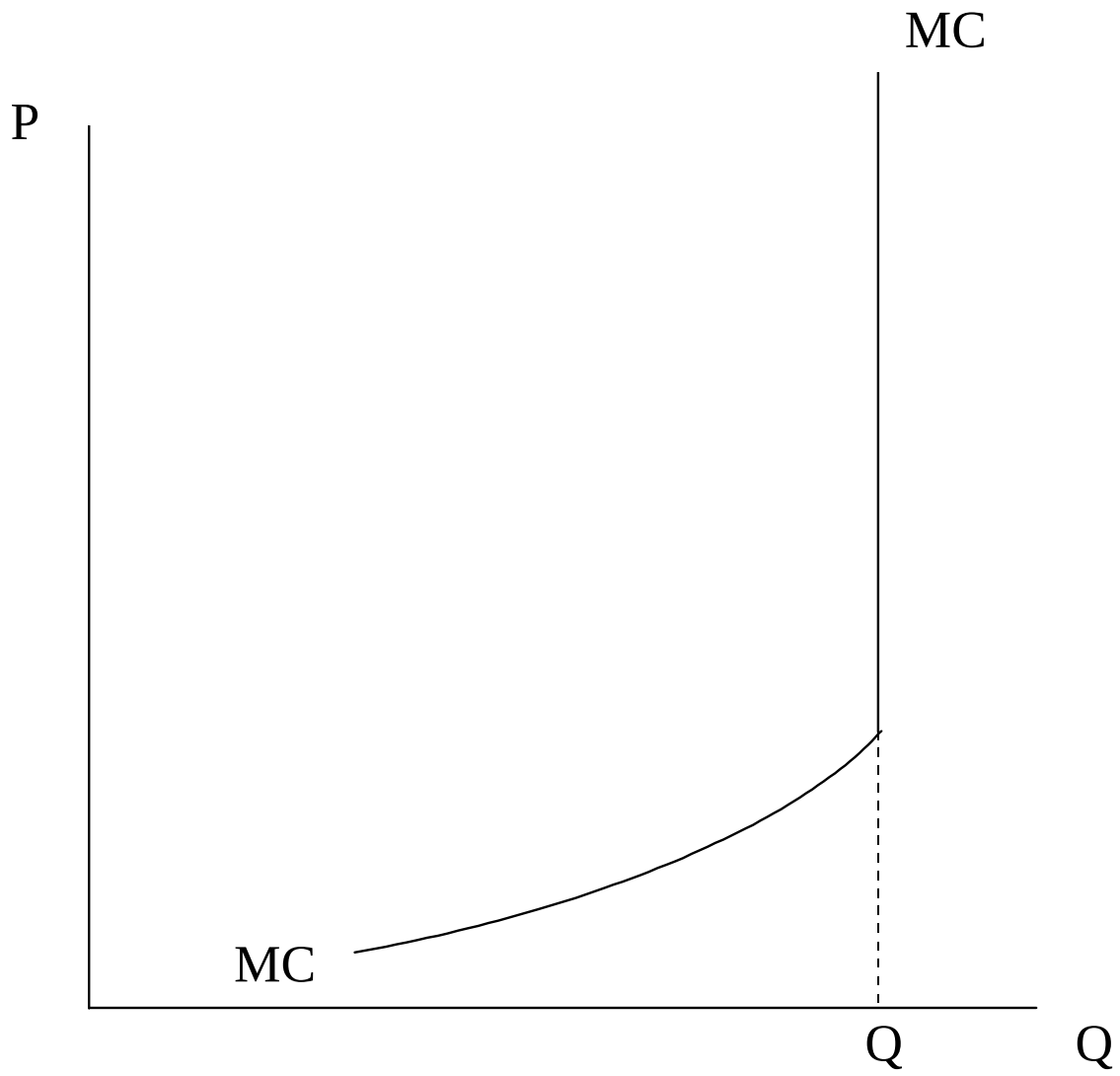

Figure 1E: Short-Term Marginal Cost with Input Constraints

where,

P	Price
Q	Output quantity
MCMC	Marginal cost curve

The changes in input prices due to policy reforms give rise to the expectation is that the wood industry's aggregate supply function shifts backwards because input costs

rise from the deregulation of price controls in 1984 and the removal of the log export ban and corporatization of the New Zealand Forest Service in 1987. The backward shift because of higher input prices is consistent with Rideout and Hesseln's (1995) work. The shift implicitly assumes that prices for solid wood products remains unchanged. The shifting back of the aggregate supply curve results in a higher equilibrium price and lower quantity produced (Figure 1F).

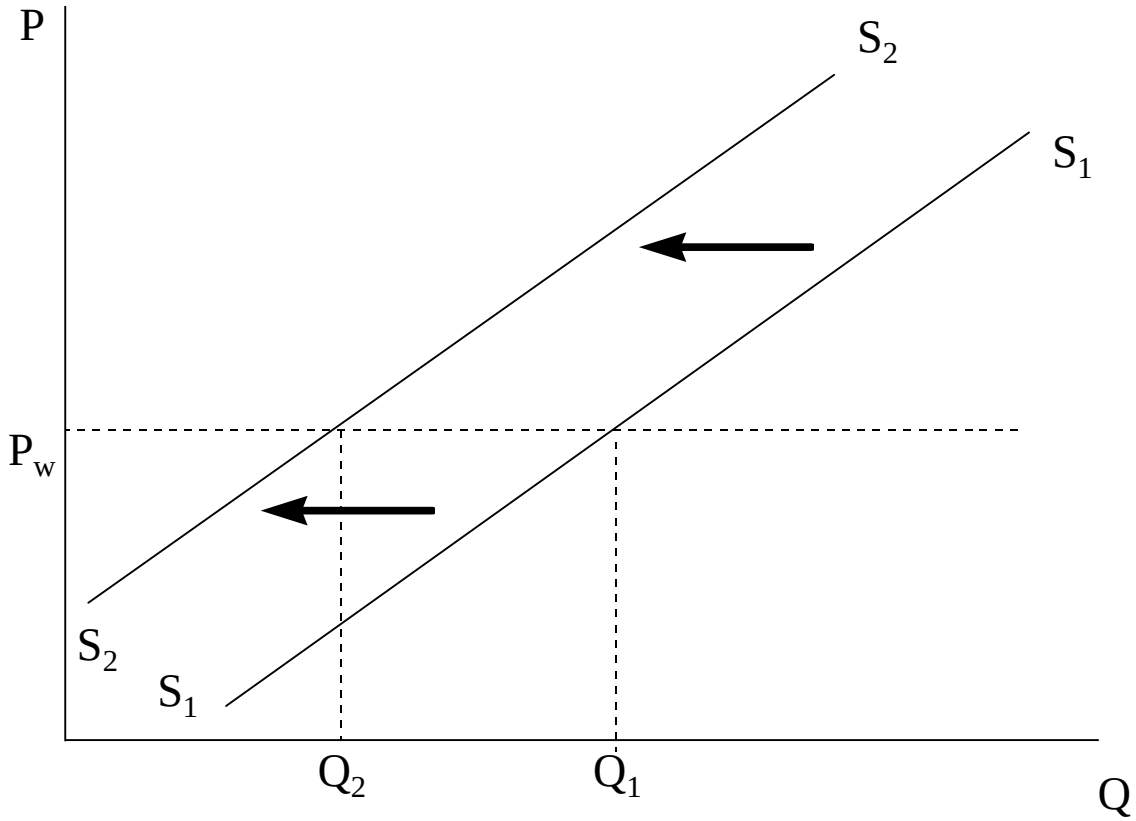

Figure 1F: Supply and Demand Curves for the New Zealand Wood Industry

where,

P	Price
P_w	World price

Q_1, Q_2 Equilibrium quantities
S_1S_1, S_2S_2, Supply curves

For the paper industry, the expectation is the deregulation of price controls may shift the sectors supply function outwards while the removal of the log export ban shifted it inwards. Although railroad reforms may have decreased transportation prices, the dispersed nature of the solid wood industry, suggesting that this reform may have had little effect on this industry. The expectation for the paper industry is that changes in stumpage prices will not affect the industry's supply function. However, changes in transportation costs may have an effect. When stumpage prices increased to world levels, rail reforms reduced the cost of transportation. This would result in a shifting out of the paper industry's aggregate supply function, leading to a lower equilibrium price and higher quantity produced (Figure 1G). When the log export ban was removed and the New Zealand Forest Service was corporatized in 1987, it is expected that the paper industry would respond in the same way as the wood industry. The paper industry's aggregate supply curve is expected to shift backwards (Figure 1G).

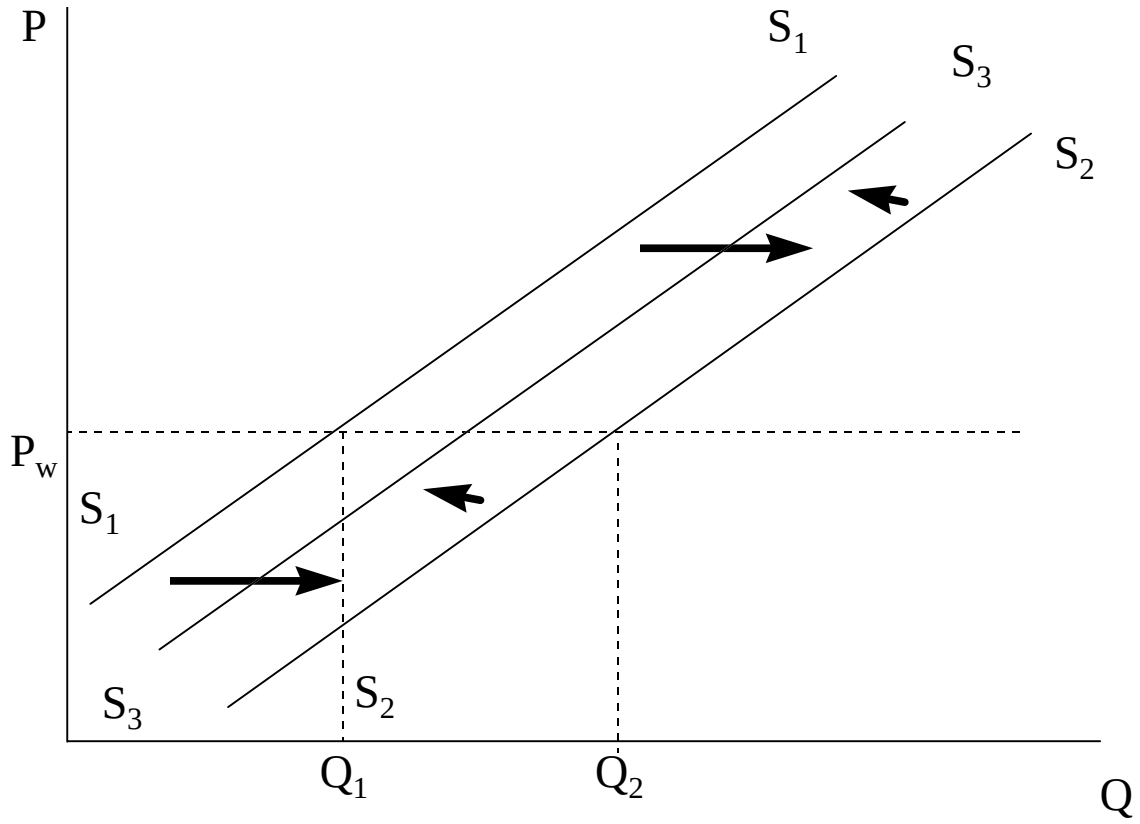

Figure 1G: Supply and Demand Curves for the New Zealand Paper Industry

where,

P	Price
Q	Quantity
P_w	World price
Q_1, Q_2	Equilibrium quantities
S_1S_1, S_2S_2, and S_3S_3,	Supply curves

This conceptual model can also be used to analyze the impacts of privatization. Privatization of the NZ Forestry Corporation started in 1990. In essence, it was a transfer of raw material inputs. The land itself was not sold off, only long-term management rights. The expectation is that this would result in a shifting out of an industry's

aggregate supply function. As an industry or firm obtains control over a raw material resources, gains may be made over the utilization of the fiber input, affecting both production and supply. This could occur for either the wood or paper processing industries.

Evidence supporting a shift in the wood and paper industry's aggregate supply function can be found by estimating the industry's aggregate production function. Including a dummy variable in the estimated production function for the deregulation of price controls in 1984, removal of log export ban and corporatization in 1987, and privatization in 1990 will indicate the significance and magnitude of a supply shift. Although a shift of the production function can be estimated, it is not a direct measure of how much the supply function shifts, but only an indicator.

Conceptual Model Two

This model analyzes the impacts on cost efficiency in the wood industry from the deregulation of price controls, removal of the log export ban and corporatization, and privatization. Cost efficiency is essentially the distance of a total cost observation from a total cost frontier. In other words, an observation is cost inefficient when the monetary expense needed to produce a given level of output is not the lowest (Figure 1H).

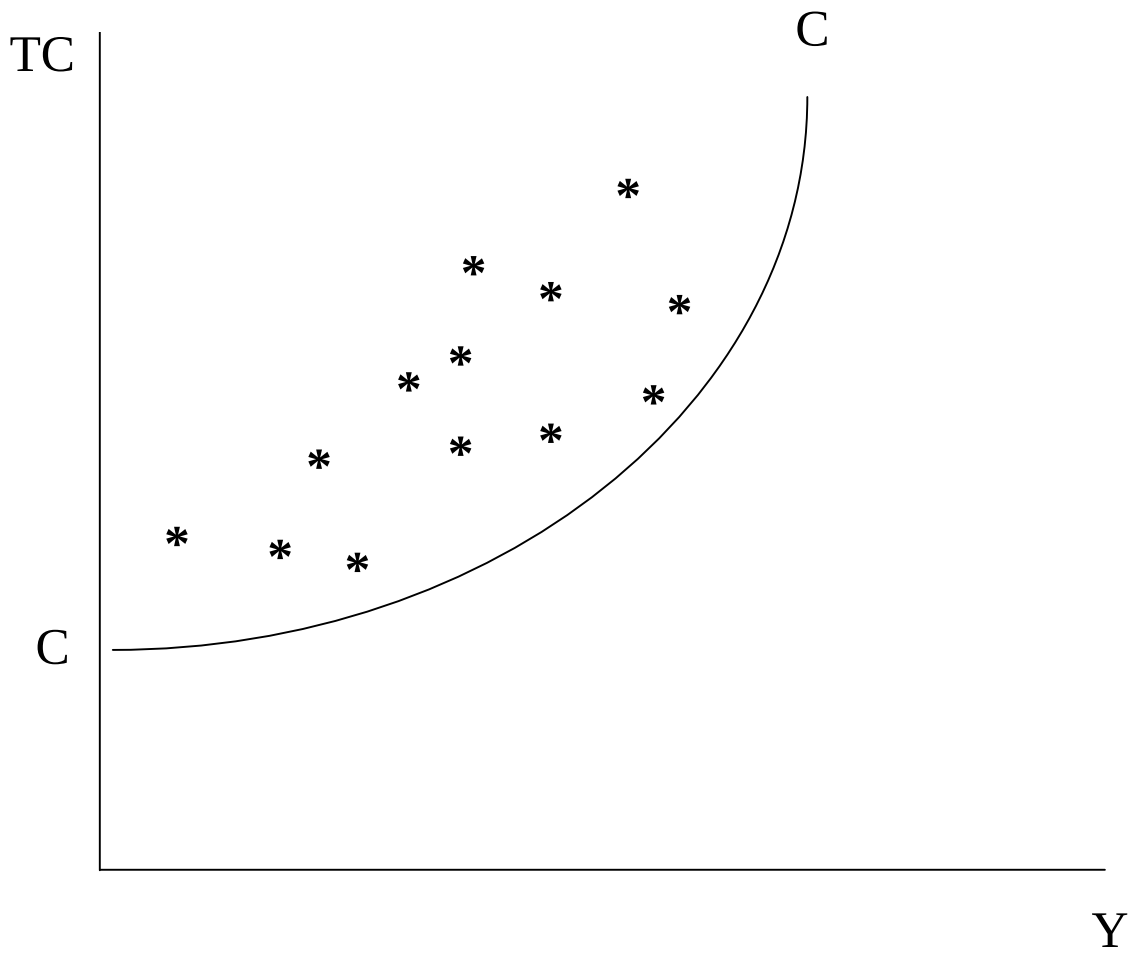

Figure 1H: Cost Efficiency Frontier

where,

TC Total cost
Y Quantity
CC Total cost frontier
* Observation

Cost efficiency can also be viewed as having allocative and technical components. Allocative efficiency is defined as when the iso-cost and iso-quant curves are tangent at point *B* in Figure 1I. Allocative inefficiency is when the output level is not

located where the two curves are not tangent. It is the distance from the iso-cost and iso-quant curves. This distance is where $1-\frac{OC}{OD}$. Technical efficiency is where outputs are produced on the iso-quant curve. Technical inefficiency is when output production is not on the iso-quant curve. This distance is where $1-\frac{OB}{OA}$. It is measured as the distance from the observation (output level) to the iso-quant curve. When a firm or industry is cost efficient then output production occurs at point *B* where the tangency of the iso-cost and iso-quant curves. Cost inefficiency occurs when output production is allocatively and technically inefficient. An example of this is when a firm or industry produces at point *E*. Figure 1I below demonstrates this fact.

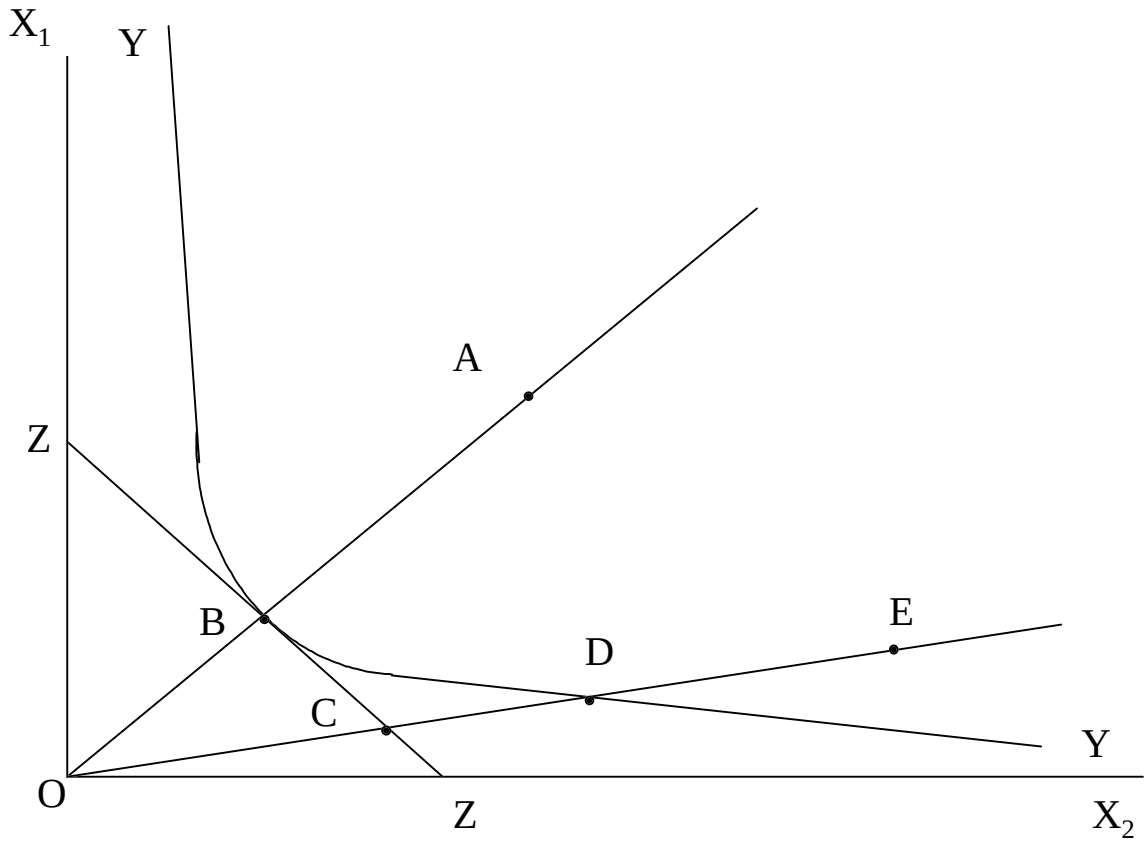

Figure 1I: The Allocative and Technical Components of Cost Efficiency

where,

ZZ Iso-cost curve
YY Iso-quant curve
B Cost efficient
A Technically inefficient
C Not feasible
D Allocatively inefficient
E Allocatively and technically inefficient
X_1, X_2 production inputs

Evidence supporting a change in cost efficiency can be found by estimating a stochastic cost frontier. Estimating this model before and after each reform will provide information on the mean cost efficiency. Comparing the differences in the mean cost efficiency before and after each policy event will allow for the calculation of percent

changes in cost efficiency as a result of each reform. The expectation is that when a protected industry adjusts to higher input costs and greater international competition, cost efficiency will decrease in the short-term. Labor and capital adjustments will impact industry and firm input costs, resulting in changes in cost efficiency.

Prelude of Research Essays

Three approaches are used to study the impacts of deregulation and privatization. These approaches are broken down into separate essays, forming the content of this dissertation. The first essay is titled: "Policy impacts on New Zealand forest industrial production structures." The second essay is called "Policy impacts on New Zealand forest industrial cost structures." The final essay is on "Policy impacts on cost efficiency in the New Zealand wood industry." The results from these essays are discussed separately and integrated in the final conclusions chapter and are abstracted below.

Chapter 2: Policy impacts on New Zealand forest industrial production structures

The lack of literature analyzing deregulation and privatization in the forestry sector prompted a creative method for policy analysis. In this chapter, shifts in the wood and paper industry's aggregate supply functions is detected by estimating each industry's production function. The shifts are expected to represent the impact of the three major policy reforms: deregulation of price controls in 1984, removal of the log export ban and corporatization of the NZ Forest Service in 1987, and privatization of the NZ Forestry

Corporation in 1990. In addition, the rate of technical change is also assessed to gather further evidence of reform policy impact. The production process for both the wood and paper processing industries are characterized by estimating Cobb Douglas, Generalized Leontief, and Translog functional specifications.

The results show that reform policy implementation shifted production downwards while the rate of technical change shifted production upward for both the wood and paper processing industry. After the removal of price controls in 1984, aggregate output increased by an average 0.09 for the paper processing industry and decreased by an average 0.12 for the wood processing industry. The responses by both industries show that the inherent inefficiencies in the wood processing industry created short term reductions in output production because of higher input prices, while the paper processing industry increased output production because of lower transportation costs. After the removal of the log export ban in 1987, aggregate output decreased by 0.25 for the wood processing industry and decreased by 0.30 for the paper processing industry. Removing trade barriers exposed inefficient mills in the New Zealand forest product processing industries that decreased output production in the short run. Higher log prices offered by international competitors decreased the raw material flow to domestic producers, causing a decrease in production. In addition, a policy reduced recession was having an impact on the impact on the supply and demand of wood and paper products. After privatization of government owned forest resources in 1990, no significant change occurred in output production for either the wood or paper processing

industries. These results show that deregulation policies had a greater impact on forest product manufacturing sector's output production than did privatization.

Chapter 3: Policy impact on New Zealand forest industrial cost structures

In this chapter, a cost function approach is used to compare reform impacts before and after each reform policy implementation. As in the first chapter, estimating the total cost function for the wood and paper industry may provide evidence supporting the notion that policy reforms shifted either industry's aggregate supply function. Although duality theory would have derived the same information, direct estimation of the total cost function can be used as a verification for production estimates. In addition, estimating the total cost function allows for white statistical noise which is represented in the model's error term. This approach included measuring the change in the rate of cost diminution to gather and assess further evidence of impacts from reform policies. The cost structure for both the wood and paper processing industries were also assessed by estimating Cobb Douglas, Generalized Leontief, and Translog functional specifications.

The results show that reform policy implementation shifted costs and changed the rate of cost diminution for both the wood and paper processing industries. After the removal of price controls in 1984, aggregate total cost did not change significantly for the wood processing industry, but the paper processing industry experienced a significant increase in total cost by 0.12. The responses show that increased production in the paper processing industry created a short-term increase in aggregate cost. After the removal of

the log export ban in 1987, aggregate total costs significantly increased by 0.15 for the wood processing industry, but significantly decreased by an average 0.09 for the paper processing industry. The exposure of domestic wood processing mills to international competitors and coupled with increasing raw material input prices increased the sub-sector's aggregate total cost. The decrease in aggregate total cost for the paper processing industry suggests that production-declines directly affected industry costs. After privatization started in 1990, aggregate total cost for the wood processing industry did not significantly change. The paper processing industry experienced a 0.07 decrease in aggregate total cost because of greater access to wood supplies and reduction in transaction costs. These results show that deregulation had a greater impact on the forest products manufacturing sector's aggregate total cost than did privatization. This resulted in shifts of the wood and paper industry's aggregate supply functions.

Chapter 4: Policy impacts on cost efficiency in the New Zealand wood industry

In this chapter, stochastic frontier models are used to measure changes in cost efficiency for the wood processing industry before and after each reform policy implementation. The stochastic frontier models are estimated using the cost function approach. The cost structure used in this analysis to characterized the wood processing industry includes both the Cobb Douglas and Translog functional specifications.

The results show that the wood processing industry's cost efficiency changed after each reform policy implementation. After the removal of price controls in 1984, the

wood industry's cost inefficiency increased by 58%, indicating that cost efficiency decreased. This result is supported by additional evidence of increased capital inflows, suggesting that the wood processing industry was attempting to incorporate new technologies that would reduce the ratio of raw material input to output because of higher input prices. This action lead to a short-run decrease in cost efficiency. After the removal of the log export ban in 1987, the wood industry's cost efficiency decreased by 372%, suggesting that cost efficiency decreased. This result and additional evidence suggest that the wood industry became less cost efficient in the short-run as it began to compete in the international marketplace. The removal of trade restrictions helped stimulate new capital investment. After privatization reforms started in 1990, the wood industry's cost efficiency decreased by 128%. This result suggests that once again increases in capital inflows from purchasing government timber resources reduced cost efficiency in the short-run as firms vertically integrated their production processes.

Chapter 5: Concluding remarks

The final chapter in my dissertation summarizes the results and policy implications put forth in Chapter's 2, 3, and 4. In general, deregulation and privatization caused dramatic changes in production and cost for the New Zealand wood and paper industries. Analysis of the wood industry shows that cost efficiency decreased after policy reform implementation, suggesting that short-term adjustments may be necessary before long-run efficiency goals are realized for countries who choose these policy-

changes. In particular, forest sectors that are highly capital intensive and have a comparative advantage may become more inefficient as inputs become more expensive through an opening of the economy.

Future research directions that may provide greater understanding of deregulation and privatization's impact on the forest sector are also discussed. These potential research directions include firm level analysis, evaluation of changing macroeconomic conditions, landowner behavior, and cross-country comparisons.

Chapter 2

Policy impacts on New Zealand forest industrial production structures

Introduction

Many countries are currently implementing deregulation and privatization. For example, the United States has deregulated it's airline and telecommunication industries, while post-communist Eastern European countries are currently restructuring their economies. Few countries have yet to deregulate or privatize their forest resources. Two exceptions are Chile and New Zealand. Chile has undergone some institutional reform (Lüder, 1991). Unlike Chile, New Zealand has implemented extensive restructuring of its forest sector as part of an overall effort to open their traditionally closed, protectionist economy (Duncan and Bollard, 1992).

Since the 1984 national elections, the New Zealand Forest Sector has undergone tremendous changes that have resulted in forest products being one of the primary export sectors. Historically, meat, wool, and other animal products dominated the export market. In 1967, 61% of total primary exports were attributed to these animal based commodities while forest products only contributed 4% of total primary exports. In 1991, animal based commodities contributed 41% of total primary exports while the forestry contribution had increased to 9% of total exports (Chatterjee, 1992).

New Zealand's radical economic reforms began with the 1984 elections. In 1984, several macroeconomic factors contributed to problems in New Zealand's economy. Although real gross domestic product (GDP) growth was over 6%, the current account balance deficit was over 8%, the governmental fiscal balance had a deficit of over 6%, and net public debt was 40% of GDP (Evans et al. 1996). Besides these macroeconomic indicators, other factors that had considerable influence in starting the radical economic reforms included poor productivity and growth performance during the previous (i.e., 1970s) decade, overly restrictive industrial regulations, a history of failed governmental stabilization polices, devaluation of the New Zealand dollar and high inflation, excessive control of special interest groups on governmental policies, a malleable political system which had a single chamber legislative body, and no constitution (Duncan and Bollard, 1992).

Soon after the July 1984 national elections, broad based reform programs were implemented in both the private and public sectors of the economy. These programs were intended to make the economy more efficient, reduce public intervention and promote increased competition in the private sector. In the forest sector, specific reform programs included the removal of incentive programs and price controls on state-owned wood, the removal of which allowed wood prices to reach world price levels (Birchfield and Grant, 1993). In addition, reforms were enacted to deregulate the NZ rail roads. These early deregulation initiatives were the start of a reform process that eventually led to the removal of the log export ban, dismantling of the New Zealand Forest Service,

along with subsequent corporatization, and the privatization of capital and land resources.

The purpose of this chapter is to examine the impacts of reform policies such as deregulation of price controls, removal of the log export ban, and privatization, on supply in the New Zealand forest manufacturing sector. As indicated in Chapter 1, impacts on industry's supply function can be detected by estimating the aggregate production function (Figures 1F & 1G). The analysis in this chapter will focus on production in the wood and paper processing industries. To date, no study has empirically analyzed production in the New Zealand solid wood and paper processing industries, and there have been no rigorous studies which analyze the impact of policy reforms on New Zealand's forest sector.

The analysis in this chapter includes four sections. Section 1 summarizes the study's problem statement. Section 2 summarizes the timing of New Zealand's public and private policy reforms, discuss the methods used to estimate the production function, and determine the rate of technical change. Section 3 summarizes the production models for the wood and paper industries. Section 4 presents results from applying the production model to New Zealand wood and paper industry data, conduct hypothesis tests, and estimate the rate of technical change. Finally, Section 5 offers conclusions and policy implications.

2. New Zealand's Deregulation and Privatization Experience

The New Zealand Forest Service was established in 1919 with the purpose of managing existing forests and preventing local wood shortfalls. Radiata pine was selected as the primary species for reforestation. By the 1980's, reforestation on state land and incentives for planting on private lands led to a production forest area base of 1.1 million acres, of which 47.3% was owned by the National government. This forest base represented a significant portion of the country's total asset portfolio (Bilek and Horgan, 1992).

Prior to the 1984 national election, the New Zealand Forest Service had several issues with which to contend. Most importantly, the agency was required to compensate for high country-wide unemployment through forced hiring of unskilled labor (Birchfield and Grant, 1993). The agency was also involved in administering costly reforestation incentive programs on private lands. Price controls were extensive, and domestic wood prices were well below world levels. A ban on exports of public-harvested wood, and increasing opposition to harvesting of native forests, also existed.

The 1984 election began a sequence of policy revisions that would change the nature of New Zealand's forest sector. All price controls were removed at once in 1984. The price control that specifically affected the NZ forest sector were that state wood prices were held to artificially low levels. The removal of this control allowed state wood prices to rise to world levels. In 1987, the public log export ban was also lifted, and the Forest Service was transformed into the "Forestry Corporation." When the Forest Service was corporatized all native forests were re-allocated to a newly created Department of Conservation. Timber harvesting on these native forests were largely

eliminated except for operations on the West coast of the South island (Duncan and Bollard, 1992). All public plantation forests remained under Forestry Corporation control. Prior to its removal, the public log export ban had provided considerable incentives for private wood suppliers to sell to foreign buyers.[2a] In 1989, in a total surprise for the forest sector, the Forestry Corporation announced intentions to sell all State commercial forest assets beginning in 1990. Given outstanding Maori land claims, the government sold cutting rights of their forest plantations for 30-40 year periods. In the first year, nearly half of the public forest plantations had been sold to private concerns, and by 1992, the government's ownership of plantations had decreased to only 17.5% of the original area (Turland, 1990; Brown and Valentine, 1994). The Forestry Corporation was finally dismantled in 1997.

The reforms and subsequent changes to the Forest Service created major adjustments within the forest sector. During the periods of deregulation between 1986 to 1989, total roundwood removals from New Zealand forests increased from 10.2 million m^3 to 11.7 million m^3, a 15 % increase, while total exports of forestry products increased 113%. In addition, high rates of return at the beginning of policy reforms encouraged development of new technologies using foreign moneys and capital. Examples of these technologies included new preservative wood treatments, green finger joining, vapor boom treatments, and wood hardening processes (Butcher, 1991). Labor productivity

[2a] The adjustments in domestic prices that occurred with deregulation and the log ban removal were substantial. In fact, the increase in domestic wood prices between 1986 and 1987 was enough to completely remove the NZ $71 million budget deficit of the Forestry Corporation (Birchfield and Grant, 1993).

increased 23%, accompanying a 29% drop in total employment within the wood industry (Evison, 1990). Privatization of the public forest base also induced major adjustments--total roundwood removals from New Zealand forests increased 40%, while exports of all forestry products increased 89%. Over 100 new wood industry mills were established between 1990 and 1995 to accommodate increased demand (NEFD, 1995).

3. Production Model Specification

Deregulation of price controls, removal of the log export ban, and privatization can potentially shift production. Rideout and Hesseln's (1985) work suggest that shifts in production result in a corresponding shift in industry supply. There are two methods proposed in the literature to estimate these shifts (Gujarati, 1988; Greene, 1997). The first estimates production function parameters for each time period, and uses a Chow test to test for shifts in the parameters over time. The second method uses dummy variables in the estimated models to test production shifts over time. The advantage of the second method is the direction of functional shift is easily discernible.[2b] In addition, estimating each industry's production function eliminates the need to derive production information from the cost function using duality theory. The key benefit from this approach is that the error term can be estimated. This error term picks up unexplained events and random noise in the data. In addition, it is mechanically easier to estimate the production function.

[2b] In addition, estimation of functional shift is computationally easier.

Reform policies can also affect the rate of technical change over time. The rate of technical change is measured by how output changes as time elapses while the input bundle is held constant. The approach used in this chapter relies on specifying a trend variable in the production function as a proxy for technical change. One important advantage of this methodology is that, when technical change is found to occur, this method can determine whether the technical change is progressive or regressive.[2c] However, the disadvantage is that the causal agents for the technical change, such as capital and labor, can not be easily determined.

The production function approach is the traditional way to test for changes in technology over time. Consider the following production function,

$$y_{jk} = f_j\left(x_{ijk}, d_g, t, \varepsilon_{jk}; \beta_{ij}\right), \tag{1}$$

where $f_j\left(x_{ijk}, d_g, t, \varepsilon_{jk}; \beta_{ij}\right)$ is an implicit production function, y_{jk} is aggregate output, x_{ijk} is aggregate input, d_g is the dummy variable for each policy event, t is the time trend, β_{ij} is the parameter set, ε_{jk} is the random error, subscript i refers to input, subscript j refers to industry, k refers to observation, and g refers to reform policy.

The rate of technical change analysis follows Chambers (1988), who defines technical change as a shift in the production function, resulting from improvements in

[2c] Progressive change is when the sign of t in equation (2) is positive and regressive when the sign is negative.

capital and/or labor saving devices. One easy way of testing for technical change is to include a time trend in the production function, and take the natural logarithm of the function before estimating the model. The rate of technical change over time can then be found by taking a first derivative of this transformed production function with respect to the time trend:

$$T_j\left(x_{ijk}, d_g, t, \varepsilon_{jk}; \beta_{ij}\right) = \frac{\partial \ln f_j\left(x_{ijk}, d_g, t, \varepsilon_{jk}; \beta_{ij}\right)}{\partial t} \qquad (2)$$

The advantage of this approach is that it is simple and additively tractable. However, it assumes that the production function has the same functional form over time. Thus, it does not address the possibility of technological changes that alter the functional form representing the production process.

4. Empirical Model

In analyzing deregulation, removal of price controls, and privatization, Cobb Douglas, Generalized Leontief, and Translog functional forms are estimated to analyze changes in production. A likelihood ratio test is used to test for the most appropriate functional form. Results indicate that the Translog is the most appropriate functional form. I estimate the other functional forms because they may provide useful information and collaborative evidence for shifts in production. In addition, the Cobb Douglas specification is common for aggregate data in technical efficiency and change work, and

forestry applications (Manning and Thornburn, 1971; Carter and Cubbage, 1994), while the Generalized Leontief and Translog are flexible functional forms (Chung, 1994).

Inputs having potential endogeneity, correlated with disturbance term, requires using a two stage least squares procedure to estimate the three functional forms. A two stage least squares procedure is used to eliminate the potential endogeneity issue. The first step in the estimation process is using ordinary least squares to estimate predicted values for endogenous factor demands. The factor demand is then examined by a comprehensive set of misspecification tests to ensure that the assumptions of normality, linearity, homoskedasticity, parameter stability and independence hold.[2d] The predicted values for the labor factor demand are then substituted into the Cobb Douglas, Generalized Leontief, and Translog production functions prior to estimation of the final production function parameters, i.e.,

Cobb Douglas Model

$$y_{jk} = \ln A_j + \sum_{i=1}^{n} a_{ij} \ln x_{ijk} + d_g + t + \eta_{jk}, \qquad (3)$$

Generalized Leontief Model

$$y_{jk} = \sum_{i=1}^{n}\sum_{m=1}^{n} \phi_j x_{ijk}^{b_{ij}} x_{mjk}^{b_{mj}} + d_g + t + \eta_{jk} \qquad (i \neq m;\ i,m=1,\ldots,n) \qquad (4)$$

[2d] See Appendix Table A1 & A2 for results and description of methods used.

Translog Model

$$\ln y_{jk} = \ln \gamma + \frac{1}{2}\sum_{i=1}^{n}\sum_{m=1}^{n}\Omega_{ij}\ln x_{ijk}\ln x_{mjk} + d_g + t + \eta_{jk} \qquad (i\neq m;\ i,m=1,\ldots,n) \qquad (5)$$

where A_j γ, $\varnothing_j$ and are a constants, a_{ij}, b_{ij}, b_{mj}, and Ω_{ij} is a parameter set, x_{ijk}, x_{mjk} are inputs, η_{jk} is the error in the second stage of estimation, and the other variables are previously defined. Homogeneity of degree one is not imposed on models (3), (4), and (5). Cross-price restrictions are imposed on specification (4) and (5) when only one cross-product of each type is included in the model.

After estimating production for the solid wood and paper processing industries, misspecification testing is conducted again as in the factor demand case. If all assumptions hold, hypothesis testing can then be conducted on parameter estimates to determine the impact of each reform policy. This procedure follows McGuirk et al. (1993).

I assume that New Zealand's reforms are realized through shifts in the production functions. This is justified given that there was very little time from the announcement of a new policy to the policies implementation. That is, the specifications in (3), (4), and (5) will not include a lagged structure. This assumption is tested in two ways. First, using McGuirk et al. (1993) procedures showed that production was independent across time because of the aggregate data. Second, distributed lag models were estimated and

showed the same result.[2e] In addition, The Economist (1996) argues that the broad scope of privatization and deregulation reforms, and their swift implementation immediately after the 1984 election, completely surprised the forest sector. Further, policies were not phased in over time; rather, deregulation of price controls and sales of state-owned assets occurred within a very short period of time after the reforms were announced. Consistent with these observations, dummy variables will be used in (3), (4), and (5) to identify and test shifts in production as a result of privatization and deregulation reforms.[2f]

Data to estimate (3), (4), and (5) come from published sources including the New Zealand Ministry of Forestry, Ministry of Commerce, and Statistics New Zealand. Appendix 2A reviews the data sources used in this study. Data consist of quarterly (seasonally unadjusted) time series with a total of 75 observations between 1977-1995. Some data transformations were necessary prior to estimation.

A. Estimating Results

Tables 2A-2B present estimates of production functions for each industry and several functional forms. An F-test was conducted to find the best specification for production in both the wood and paper industries. Results show that either the Cobb Douglas or Translog models can best represent the wood and paper industries. The Generalized Leontief specification is not appropriate for this data, however, the results

[2e] See Appendix Table B1 & B2.
[2f] Chow tests were also used to verify the functional shifts we find with the dummy variables. The results are available from the author.

from this estimation are consistent with the other production models.[2g] Each functional form incorporates dummy variables depicting the removal of price controls in 1984 (D_1), removal of the log export ban in 1987 (D_3), and privatization reforms in 1990 (D_2). The estimates for all specifications could not be rejected for the presence of normality, linearity, homoskedasticity, parameter stability, and non-autocorrelation.[2h] Likelihood ratio tests will be used to indicate response differences between industries.

A.1. Deregulation

Table 2A presents unrestricted Cobb Douglas, Generalized Leontief, and Translog production function estimates for the wood industry form 1977-95. Coefficient estimates for raw material input are significant for the Cobb Douglas form and positive for all variables. The parameter estimates for capital (X_2) are significant only for the Cobb Douglas form, but positive for all.[2i] The labor coefficient estimates were only significant for the Translog form, but had negative signs. This finding may be a result from an outflow of labor from the wood industry (Evison, 1990). Coefficients for deregulation of price controls are significant at the 10% level and negative, suggesting that the wood industry's aggregate production function shifted significantly downwards which indicates a backward shift in industry supply (Figure 1D & 1F).[2j] This may have been caused from the persistence of outdated mills, paying high material input prices when the economy opened. The estimate for the removal of the log export ban was only

[2g] See Appendix Table C1
[2h] The results of these tests are available from the author upon request.
[2i] Note that these results are consistent with properties of production functions. Although the labor coefficient contradicts these properties, Harris (1993) got similar results.

significant for the Cobb Douglas form, but was negative for all, suggesting another downward shift. Evison's (1990) study supports this result. He argues the ban removal allowed log owners to obtain higher returns by exporting their logs. In turn, this created a short term input constraint for domestic producers, thus reducing output (Figure 1E). Further analysis of the coefficients show that the responses after each policy event were greater after the log export ban removal than for deregulation of price controls. This difference may reflect the unrestrained competition impacting the industry.

Table 2B presents Cobb Douglas, Generalized Leontief, and Translog production function parameter estimates for the paper industry for 1977-1995. Coefficient estimates for raw material input are only significant for the Cobb Douglas form. The Translog estimate is positive, but not significant. The inconsistency with production function properties may correspond to the reduction of raw material use and output over time. The capital coefficient is significant and positive for the Translog form, but not for the Cobb Douglas specification. The labor coefficient is significant, negative for the Cobb Douglas form, and consistent with the wood industry's corresponding estimates.

The coefficients for deregulation of price controls are significant at the 5% level and positive, suggesting that the paper industry's aggregate production function shifted upward and indicating that the industry's supply function shifted outward (Figure 1B). This response may have been caused by the ability of the paper producers to capture additional supplies of raw materials. Although the pulpwood market would be unaffected by higher log prices, solid wood mill owners would have increased

[2j] Refer back to conceptual model on page 13.

availability of chips as a way to utilize waste streams. In addition, most paper product mills were located on the North Island and justified the hauling costs from remote locations because of the economies of scale gains (Neilson and Smith, 1994). In addition, deregulation of rail ways decreased freight rates, decreasing costs of setting raw material fiber to mills (Duncan and Bollard, 1992). These events may have lead to the shifting of the paper industries aggregate production function in 1984. The coefficient for the removal of the log export ban is significant at the 1% level and negative across forms. This result corresponds to the wood industry's response. The increased competition for raw material resources by international buyers provoked a reduction in output in the paper industry.

Deregulation and privatization caused production function shifts in both the wood and paper industries. These differences can be examined more closely by comparing the significance, signs, and magnitudes of each industry's coefficients.[2k] In all cases, the parameter estimates for capital suggest that it had a greater impact on paper production than wood. After the removal of price controls, both industries responded differently. Paper industry production increased while wood industry production decreased. The higher material prices allowed the paper industry to capture additional fiber supplies because of lower railway costs. After the removal of the log export ban and corporatization of the Forest Service in 1987, production decreased for both the solid wood and paper industries. The Forestry Corporation, mandated to be a profit maximizer

[2k] Likelihood ratio tests were conducted to verify response differences across industries. Table 2C shows that the wood and paper industries responded significantly different to deregulation and privatization.

could get a greater rate of return by selling logs to international competitors than to domestic wood and paper mills. In addition, the economy was in a policy reduced recession which may have decreased demand for many goods (Dalziel and Lattimore, 1996). After the removal of the log export ban, production across industries decreased because of greater international competition (Figure 1D). Likelihood ratio tests suggest that despite reduced production, responses differed in magnitude across industries. For both deregulation reforms, removal of the log export ban had a greater effect on each industry than did deregulation of price controls.

A.2. Privatization

Table 2A and 2B present coefficients for privatization dummy variables for each industry across functional forms. Coefficients for the wood industry are not significant at any level across functional forms. Although this suggests little or no production response to privatization, the signs are negative. The negative sign across all specifications suggests that domestic producers dependent on government raw material were unable to secure a fiber supply from privatization reforms. This may have resulted in reduced levels of output. The parameter estimates for privatization are also not significant for the paper industry. As in the wood industry case, this suggests little or no production response to privatization reforms. Unlike the wood industry case, the sign is positive, suggesting that the paper industry may have been able to secure raw material resources from the privatization process. This occurred, because domestic paper producers did control large timberland resources prior to privatization (Neilson and Smith, 1994). Immediately after privatization in 1990, the Carter Holt Harvey and

Fletcher Challenge corporations, large producers of pulp and paper, increased their holdings of timberlands from 5.2% and 11.5% to 26.8% and 15.7%, respectively (Bilek and Horgan, 1992).

Deregulation and privatization affected production in the New Zealand wood and paper industries, however, the production response was greater for deregulation than for privatization. Production decreased for the wood industry after the removal of price controls, while paper industry production increased. These results suggest that input costs increased in the wood industry, and the paper industry was able to exploit a deregulation of the railways to capture additional fiber supplies. After the removal of the log export ban, all functional forms showed decreased production for the wood and paper processing industries. This reform policy allowed the government and private timber growers to sell logs to the highest bidder. Foreign buyers such as the Australians, Japanese, and Chinese out competed domestic processing mills for fiber. This caused an input constraint of raw material that could have resulted in decreased production for both industries (Figures 1D & 1E).

Across functional forms, neither industry responded significantly to privatization. Changing the ownership structure of the forest sector allowed firms to secure raw material resources for production, but the limited timberlands in New Zealand forced firms to acquire wood from other sources. Thus, privatization did not appreciably affect input prices and cause shifts in aggregate production for either industry. The key result from estimating these production models is that deregulation had a greater impact on production for both the wood and paper processing industries than did privatization.

5. Model Extensions

An extension of the production models estimated above is to evaluate the impact of policy reforms on the rate of industry technical change. As described earlier, the rate of technical change is easily determined by adding a trend variable to the production function and evaluating its first order properties with respect to time. This corresponds to a shift in the industry's production function. Chambers (1988) suggests that technological improvements should shift the production function upward.

The rate of technical change is positive for both wood and paper industries across functional forms. In the wood industry, only the Translog model has a negative sign, but it is not significant at any level. In the paper industry, all functional forms show a positive time trend.[21]

Both industries experienced progressive technical change, suggesting that technological improvements pushed the production function upwards for both industries. This is an interesting result. While deregulation and privatization reforms were shifting back the production function, new capital investment slowly led to increased production. Improvements in technologies such as the introduction of green finger jointing, vapor boom treatments, and wood hardening processes have obviously contributed to these observations (Butcher, 1991). In addition, technological change is more than capital investment. It can also be a change in training, labor flexibility, production planning and

[21] The insignificance of the time trend in both cases may have resulted from the limited number of observations.

flow, and mill management. A similar response occurred with the paper industry, as new paper facilities with improved technologies and greater production capacity came on-line (Neilson and Smith, 1994).

Another interesting result comes from comparing the coefficient changes between the rate of technology change, and deregulation and privatization dummy variables. In the wood and paper industry, deregulation and privatization generally depressed production because of higher input prices, fiber shortages, and integration costs of former public timberlands. Although policy reforms decreased production, new capital investment increased production by shifting the production function upward. The magnitude and significance of the coefficients in Table 2A & 2B show that the effect of policy reforms had were more significant on production in both industries than the introduction of new technologies.

6. Concluding Remarks

This study's premise was to test the impacts of deregulation of price controls, removal of the log export ban, and privatization of public forest plantations on the New Zealand forest manufacturing sector. These reforms are expected to shift both the wood and paper industry's aggregate supply function. This is estimated by specifying each industry's production function, including dummy variables to examine policy impacts on wood and paper industry production. The first reform policy that the New Zealand forest manufacturing sector experienced was the removal of price controls in 1984. The results across production models give mixed responses between industries. After the removal of

price controls, production decreased in the wood industry while production increased in the paper industry. In the wood industry, raw material costs increased and capital investment rose by 372.51%. These higher input costs decreased solid wood industry production. The paper industry was able to take advantage of this decline in wood manufacturing to increase production.

The second reform policy that the New Zealand forest manufacturing sector experienced was the removal of the log export ban in 1987. This corresponded with the dismantling of the New Zealand Forest Service and creation of the New Zealand Forestry corporation. The implementation of this reform decreased production in both the wood and paper processing industries, resulting in a shifting back of both industry's supply functions. When the log export ban was removed, private timberland owners and the New Zealand Forestry Corporation sold their logs to the highest bidder. International buyers such as the Australians, Japanese, Chinese and Koreans were initially more efficient than previously-protected domestic producers of fiber. This created a input constraint that caused lower levels of production for both the wood and paper processing industries. In this respect, the paper industry was more adversely affected than the wood industry.

The last reform policy that the New Zealand forest manufacturing sector experienced was privatization, in 1990. The aim of privatization was to sell long-term management rights of timberlands and mills to private entrepreneurs. Privatization did not have a significant impact on either the wood or paper processing industries. Additional evidence suggests that, if any impact occurred, both industries responded

differently. This can be shown by the fact that the paper industry secured a source of raw material by purchasing government timberland.

The contribution this study offers is its comparative analysis of how deregulation and privatization affected the New Zealand forest manufacturing sector using an econometric approach. This study specifically focuses on the impacts of these policy events on production functions and the rate of technical change. Currently no econometric study exists that addresses these types of policy reforms for the forest sector in New Zealand or elsewhere.

There are several policy implications that one can draw from this study. The first concerns the impacts of deregulation. Deregulation leads to short-run fluctuations in production the wood and paper processing industries, affecting aggregate supply. These fluctuations are caused by the industries trying to adapt to new operating environments. Inflows of capital investment are made to make existing production systems more productive and efficient. The time required to install new equipment and build new facilities may create disruptions to the production process that reduces output.

The second policy implication is that trade reforms may lead to greater production and cost fluctuations than other restructuring policies. Trade reforms expose domestic industries to increased international competition. This increased competition will force domestic manufacturers to increase capital investment in order to become more productive and efficient. If these manufacturers can not compete in this new environment, they will fail and capital will shift into other sectors. In addition, the boom in the log exports improved the trade balance.

The third policy implication is that forest sectors that are highly capital intensive and have a comparative advantage may become more inefficient in the short run, especially if inputs become more expensive as the economy opens. As the New Zealand economy opened, capital investment increased in the forest manufacturing sector despite a decrease in wood industry production. This suggests that investors viewed the New Zealand forest products industrial base as having a comparative advantage over other sectors of the economy. The sector's high rates of return facilitated the inflow of capital. At some point when enough capital has entered the economy, the rates of return for capital will decrease. In New Zealand, the evidence of this is the decline in long-term interest rates in the 1990s from highs during the 1980s.[2m]

The fourth policy implementation is that the New Zealand experience may be used as a guide for countries with large public forest owner-ships. Currently, Australia, Canada, several Latin American countries, and the United States are considering deregulation and privatization reforms for the forest sector. Australia is probably further along this route than the other countries. Hall's (1997) study suggests keeping in mind the special conditions in New Zealand, such as an extensive exotic plantations and history of government production enterprises, before implementing privatization reform in hope of duplicating New Zealand's experience. Hall concludes that, for the United States, privatization programs should be limited to some National forest lands where wood production is the emphasis. In addition, Hall suggests that reform proceed slowly,

[2m] For example, trend analysis of data published by Statistics New Zealand clearly shows a dramatic drop in long term interest rates in the 1990's.

and cautiously incorporate a trial and error period to develop appropriate procedures before mass implementation. Hall's conclusion and the results of this study suggest the possibility of implementing privatization in a limited sense to forest sectors outside New Zealand. What I find concerning new technology investment certainly supports his claims. Perhaps a greater rate of technology adoption prior to reform implementation would have minimized the shocks on the industries and improved welfare gains.

Future research in studying the impacts of deregulation and privatization is needed not only for New Zealand but for other countries considering the implementation of these programs. An extension of this analysis for New Zealand should consider two things. First a measure other than exports should be used as the dependent variable for the wood and paper industry production functions. This is because exports may not be a constant proportion of annual total industry outputs. Second, the data for capital input is not adjusted for capital depreciation. Incorporating this assumption, may provide additional information. In further advancing this work, effort should be given to obtain firm level panel data for those corporations that existed before and after each policy to examine the impacts of these policy events in more detail. In addition, better supply and demand data could be compiled to specify a simultaneous equation model to represent both the wood and paper industries.

Table 2A: Parameter Estimates for Production Functions in the New Zealand Wood Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	1.81	34.10***	1085.7
	(1.98)	(5.91)	(736.3)
X_1 (Raw Material)	0.49***	--	5.64
	(0.03)		(4.30)
X_2 (Capital)	0.17**	--	1.85
	(0.08)		(5.29)
X_3 (Labor)	-0.19	--	-146.01*
	(0.12)		(88.36)
X_4 (Energy Use)	0.12	--	-67.84
	(0.13)		(59.83)
X_{11}	--	$0.3x10^{-3}$	0.18***
		$(0.1x10^{-2})$	(0.04)
X_{22}	--	$-0.7x10^{-4}$	-0.03
		$(0.6x10^{-4})$	(0.04)
X_{33}	--	$-0.4x10^{-2}$	6.48
		$(0.2x10^{-2})$	(5.19)
X_{44}	--	$0.4x10^{-5}$	0.76
		$(0.9x10^{-4})$	(2.65)
X_{12}	--	$0.8x10^{-3}$**	0.04*
		$(0.3x10^{-3})$	(0.02)
X_{13}	--	$-0.1x10^{-2}$	-0.51**
		$(0.3x10^{-2})$	(0.26)
X_{14}	--	$0.1x10^{-2}$***	-0.16
		$(0.4x10^{-3})$	(0.22)
X_{23}	--	$0.3x10^{-2}$***	0.23
		$(0.6x10^{-3})$	(0.32)
X_{24}	--	$-0.5x10^{-3}$***	-0.31
		$(0.1x10^{-3})$	(0.27)
X_{34}	--	$0.3x10^{-3}$	6.79*
		$(0.1x10^{-2})$	(3.64)
D_1 (Deregulation of Price Controls)	-0.12***	-4.09***	-0.06*
	(0.04)	(0.96)	(0.03)
D_2 (Removal of Log Export Ban)	-0.04	-1.20	-0.05
	(0.04)	(1.05)	(0.05)
D_3 (Privatization)	-0.25***	-2.29	-0.02
	(0.42)	(1.39)	(0.07)
T (Rate of Technical Change)	0.01***	0.16***	$-0.1x10^{-3}$
	$(0.2x10^{-2})$	(0.06)	$(0.2x10^{-2})$

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels.
Parenthesis is standard error.

Table 2B: Parameter Estimates for Production Functions in the New Zealand Paper Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	22.57***	5.42	52.02
	(3.94)	(7.52)	(308.7)
X_1 (Raw Material)	-0.15**	--	7.82
	(0.07)		(15.25)
X_2 (Capital)	$-0.5x10^{-2}$	--	10.95**
	(0.03)		(5.53)
X_3 (Labor)	-1.69***	--	$0.3x10^{-3}$
	(0.27)		$(0.3x10^{-2})$
X_4 (Energy Use)	-0.04	--	-17.67
	(0.15)		(44.44)
X_{11}	--	-0.29***	-2.89*
		(0.08)	(1.74)
X_{22}	--	$-0.1x10^{-4}$	-0.01
		$(0.2x10^{-4})$	(0.09)
X_{33}	--	$0.2x10^{-2}$*	$0.2x10^{-7}$
		$(0.1x10^{-2})$	$(0.4x10^{-7})$
X_{44}	--	$0.4x10^{-4}$***	1.79
		$(0.1x10^{-4})$	(3.17)
X_{12}	--	$0.4x10^{-2}$**	0.30
		$(0.2x10^{-2})$	(0.26)
X_{13}	--	0.04**	$0.5x10^{-4}$
		(0.02)	$(0.2x10^{-3})$
X_{14}	--	$0.2x10^{-2}$**	0.33
		$(0.9x10^{-3})$	(1.29)
X_{23}	--	$0.8x10^{-3}$***	$0.9x10^{-5}$
		$(0.3x10^{-3})$	$(0.5x10^{-4})$
X_{24}	--	$-0.1x10^{-3}$***	-0.87**
		$(0.2x10^{-4})$	(0.42)
X_{34}	--	$-0.9x10^{-3}$***	$-0.3x10^{-4}$
		$(0.2x10^{-3})$	$(0.2x10^{-3})$
D_1 (Deregulation of Price Controls)	0.09**	-1.18	0.15**
	(0.05)	(1.01)	(0.06)
D_2 (Removal of Log Export Ban)	0.01	1.32	0.11
	(0.06)	(0.98)	(0.08)
D_3 (Privatization)	-0.30***	-2.29***	-0.30***
	(0.04)	(0.49)	(0.06)
T (Rate of Technical Change)	0.01***	0.08***	$0.3x10^{-2}$
	$(0.2x10^{-2})$	(0.02)	$(0.3x10^{-2})$

Note: * significant at the 10% level; ** significant at the 10% and 5% levels;
*** significant at the 10%, 5% and 1% levels. Parenthesis is standard error.

Table 2C: Likelihood Ratio Test on Production Functions for the New Zealand Wood and Paper Industries

Wood Time	Paper Time	χ^2 Test Statistic	Functional Form	Approach
77-84	77-84	-17.27	Cobb Douglas	Production
84-95	84-95	-42.53*	Cobb Douglas	Production
77-90	77-90	-8.44	Cobb Douglas	Production
90-95	90-95	-55.46***	Cobb Douglas	Production
77-87	77-87	0.24	Cobb Douglas	Production
87-95	87-95	-20.54	Cobb Douglas	Production
77-84	77-84	49.39***	Generalized Leontief	production
84-95	84-95	62.53***	Generalized Leontief	production
77-90	77-90	95.23***	Generalized Leontief	production
90-95	90-95	38.04***	Generalized Leontief	production
77-87	77-87	78.99***	Generalized Leontief	production
87-95	87-95	55.72***	Generalized Leontief	production
77-90	77-90	-108.96***	Translog	production
90-95	90-95	-551.54***	Translog	production

Note: numbers in the above table were rounded to two significant digits after calculating the test statistic, therefore readers calculating the test statistic using the above numbers may find small discrepancies due to rounding by the author. * significant at the 10%; ** significant at 10% and 5% levels; *** significant at 10%, 5%, and 1% levels.

6. Appendix 2A: Description of Data used in Chapter 2

Data used in estimating the Cobb-Douglas, Generalized Leontief, and Translog production models for both the New Zealand wood and paper industry came from three sources. They are the New Zealand Ministry of Forestry and New Zealand Ministry of Commerce. Energy use data for both the wood and paper industry came from the Ministry of Commerce. All other data used in this chapter came from the NZ Ministry of Forestry.

Data was available as quarterly or annual time series from 1977-95 as outlined in Appendix Table 2A1 below. The final number of observations for model estimation is 75. Annual data were linearized into quarters to provide a greater number of observations. Data that was linearized included export wood and paper volumes (Y), raw material input for both industries (X_1), and energy use for both industries (X_4). Data for capital (X_2) and labor (X_3) was available for quarters. Capital (X_2) does not include any modifications for distinguishing losses from depreciation or new investments.

Export wood and paper volumes are used as proxies for wood and paper industry aggregate output. Both data are aggregated by the New Zealand Ministry of Forestry. Total production data exists for sub-industries of the two aggregate groups, but no satisfactory means was found to aggregate the information. In addition, data for the independent variables was only available at the aggregate industry level.

Appendix Table 2A: Data Description of Production Functions in the New Zealand Wood Industry

Variable Symbol	*Variable*	*Data*	*Time*	*Type*	*Source*
Wood Processing Industry					
Y	Output	Export wood volume	1976-1995	Annual	NZ Ministry of Forestry
X_1	Raw material	Logs & poles	1976-1995	Annual	NZ Ministry of Forestry
X_2	Capital	Additions to fixed assets	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
X_3	Labor	Hours worked	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
X_4	Energy	Energy use	1977-1995	Annual	NZ Ministry of Commerce
D_1	Deregulation of price controls	Dummy variable 0's until 1984, then 1's afterwards	1977-1995	Quarterly	--
D_2	Removal of the log export ban	Dummy variable 0's until 1987, then 1's afterwards	1977-1995	Quarterly	--
D_3	Privatization	Dummy variable 0's until 1987, then 1's afterwards	1977-1995	Quarterly	--
T	Technical change	Time trend	1977-1995	Quarterly	--

Appendix Table 2B: Data Description of Production Functions in the New Zealand Paper Industry

Paper Processing Industry					
Y	Output	Export paper products volume	1977-1995	Annual	NZ Ministry of Forestry
X_1	Raw material	Wood chips	1976-1995	Annual	NZ Ministry of Forestry
X_2	Capital	Additions to fixed assets	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
X_3	Labor	Hours worked	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
X_4	Energy	Energy use	1977-1995	Annual	NZ Ministry of Commerce
D_1	Deregulation of price controls	Dummy variable 0's until 1984, then 1's afterwards	1977-1995	Quarterly	--
D_2	Removal of the log export ban	Dummy variable 0's until 1987, then 1's afterwards	1977-1995	Quarterly	--
D_3	Privatization	Dummy variable 0's until 1987, then 1's afterwards	1977-1995	Quarterly	--
T	Technical change	Time trend	1977-1995	Quarterly	--

Chapter 3

Policy impacts on New Zealand's industrial cost structures

Introduction

In the previous chapters, I have looked at how changes in production can shift the aggregate supply functions for both the wood and paper processing industries. For both industries, the implementation of deregulation and privatization reforms resulted in production and supply shifts for the both industries (Figures 1F & 1G). After the removal of price controls, the wood industry's production function shifted downwards while the paper industry's production function shifted upwards. After the removal of the log export ban and corporatization, the production function for both industries shifted downward (Figure 1D). Change in production for either industry could not be determined after privatization in 1990. In this chapter, the purpose is to confirm reasons behind these shifts by estimating total cost functions for the New Zealand wood and paper processing industries.

The purpose of this chapter is to examine the impacts of deregulation of price controls, removal of the log export ban, and privatization on total cost structures in the New Zealand forest manufacturing sector. The intent is to analyze whether these reforms had coinciding impacts on total cost as on production. The analysis in this chapter

includes four sections. Section 1 summarizes the study's problem statement. Section 2 summarizes the timing of New Zealand's public and private policy reforms, show how to estimate cost functions and determine the rate of cost diminution. Section 3 summarizes the models for the wood and paper industries. Section 4 presents results from applying the models to New Zealand wood and paper industry data, conduct hypothesis tests, and estimate the rate of cost diminution. Finally, Section 5 offers conclusions and policy implications.

2. New Zealand's Deregulation and Privatization Experience

Prior to the start of economic reforms in 1984, New Zealand was a socialist society that was involved in all sectors of the economy. During the 1950s and 1960s, there was low unemployment and its standard of living was considered to be one of the highest in the world (Colin, 1992). However, things started to change in the 1970s. Great Britain, New Zealand's leading purchaser of its export commodities, joined the European Economic Union (EEU). After which its importance in New Zealand trade began to decline despite New Zealand's favored nation trading status. In addition, the 1973 oil crisis precipitated annual rates of inflation between 10-15% until the early 1980s. Worsening macroeconomic conditions, was accompanied by raising unemployment which was previously unheard of in the recent New Zealand memory. New socio-economic programs to remedy some of the problems pushed the national debt to 40% of Gross Domestic Product (GDP).

In 1984, the Labour party won the national election. To the surprise of everyone, the implemented a extensive economic restructuring program for all sectors of the economy. These reforms included deregulation and privatization programs. In the forest sector, reforms that had the biggest impact were the deregulation of price controls and the railways in 1984, the removal of the log export ban and corporatization of the New Zealand Forest Service in 1987, and privatization of the New Zealand Forestry Corporation in 1990. Prior to the trade reforms and corporatization in 1987, the log export ban had provided considerable incentives for private wood suppliers to sell to foreign buyers.[3a] In 1989, in a total surprise for the forest sector, the Corporation announced intentions to sell all State commercial forest assets beginning in 1990. In the first year, nearly half of the public forest land assets had been sold to private concerns, and by 1992, the government's ownership of forest land had decreased to only 17.5% (Turland, 1990; Brown and Valentine, 1994).

The reforms and subsequent changes to the Forest Service created major adjustments within the forest sector. During the periods of deregulation between 1986 to 1989, total roundwood removals from new Zealand forests increased from 10.2 million m^3 to 11.7 million m^3, a 15 % increase, while total exports of forestry products increased 113%. In addition, high interest rates at the beginning of policy reforms encouraged development of new technologies using foreign moneys and capital. Examples of these

[3a] The adjustments in domestic prices that occurred with deregulation and the log ban removal were substantial. In fact, the increase in domestic wood prices between 1986 and 1987 was enough to completely remove the NZ $71 million budget deficit of the Forestry Corporation (Birchfield and Grant, 1993).

technologies included new preservative wood treatments, green finger joining, vapor boom treatments, and wood hardening processes (Butcher, 1991). Labor productivity increased 23%, accompanying a 29% drop in total employment within the wood industry (Evison, 1990). Privatization of the public forest base also induced major adjustments--total roundwood removals form New Zealand forests increased 40%, while exports of all forestry products increased 89%. Over 100 new wood industry mills were established between 1990 and 1995 to accommodate increased demand (NEFD, 1995).

3. Total Cost Model Specification

The effects of deregulation and privatization on an economy are revealed through shifts in the total cost function and changes in the rate of cost diminution. For observing and testing functional shifts over time, the primary method used in this study is to estimate total cost functions for each industry using dummy variables depicting reform policies of the removal of price controls, removal of the log export ban, and privatization.

The implicit total cost function estimated in this chapter is,

$$C_{jk} = f_j\left(w_{ijk}, y_{jk}, d_g, t, \beta_{ij}, \varepsilon_{jk}\right), \qquad (1)$$

where $f_j\left(w_{ijk}, y_{jk}, d_g, t, \beta_{ij}, \varepsilon_{jk}\right)$ is an implicit total cost function, C_{jk} is total cost, w_{ijk} is input price, y_{jk} is aggregate output, d_g is the dummy variable where g is policy event, t is the

time trend, β_{ij} is the parameter set, ε_{jk} is the random error, subscript *i* refers to input, subscript *j* refers to industry, and *k* refers to observation.

In addition to estimating total cost shifts, it is also useful to estimate the rate of cost diminution over time. Chambers (1988) roughly defines the rate of cost diminution as a shift in the total cost function. One easy method for doing this is to include a time trend in the total cost function and take the natural logarithm of the function before estimating the model. The rate of cost diminution over time can then be found by taking a first derivative of the total cost function with respect to the time trend. The rate of cost diminution is thus defined as:

$$\theta_j\left(w_{ijk}, y_{jk}, d_g, t, \beta_{ij}, \varepsilon_{jk}\right) = \frac{\partial \ln f_j\left(w_{ijk}, y_{jk}, d_g, t, \beta_{ij}, \varepsilon_{jk}\right)}{\partial t} \qquad (2)$$

where $f_{jk}\left(w_{ijk}, y_{jk}, d_{ig}, t, \beta_{ij}, \varepsilon_{ijk}\right)$ is the implicit total cost function, w_{ijk} is input price by time and industry, y_{jk}, d_g, t, β_{ij} and ε_{jk} are as previously defined. Equation (2) suggests that as technical change occurs, costs diminish.

4. Empirical Model

Three functional forms are used to estimate cost functions: Cobb Douglas, Generalized Leontief, and Translog. The Generalized Leontief and Translog are flexible functional forms (Chung, 1994). For cost functions used in this study to conform to economic theory, restrictions were placed on them. There are four properties that cost

functions must satisfy to conform to economic theory. These are non-decreasing in w_{ijk}, homogeneous of degree 1 in w_{ijk}, concave in w_{ijk}, and continuous in w_{ijk}.

The total cost models that I specify and estimate in this study are:

Cobb Douglas Model

$$LnC_{jk} = \ln \zeta_j + \sum_{i=1}^{n} a_{ij} \ln w_{ijk} + \ln y_{jk} + d_g + t + \eta_{jk} \qquad (3)$$

Generalized Leontief Model

$$C_{jk} = \sum_{i=1}^{n} \sum_{j=1}^{n} \theta_j w_{ijk}^{\psi_{ij}} w_{mjk}^{\psi_{mj}} + d_g + t + \eta_{jk} \qquad (i \neq m;\ i,m=1,\ldots,n) \qquad (4)$$

Translog Model

$$\ln C_{jk} = \ln \delta_j + \Gamma_{ij} \ln y_{jk} + \sum_{i=1}^{n} b_{ij} \ln w_{ij} + \frac{1}{2} \gamma_{ij} \left(\ln y_{jk} \right)^2 + \frac{1}{2} \sum_i \sum_m b_{ij} \ln w_{ijk} \ln w_{mjk} + d_g + t + \eta_{jk} \qquad (5)$$

where ζ_j, δ_j, and θ_j are a constants, a_{ij}, ψ_{ij}, ψ_{mj}, b_{ij}, Γ_{ij}, and γ_{ij} are parameters to estimate, η_{jk} is the error, $i=1,\ldots,n$, $m=1,\ldots n$, and all variables are previously defined. A cost function property imposed on both functional forms is homogeneity of degree one with respect to input prices. This property is imposed in reduced form so it is not expected to have the parameter estimates to sum to one. One restriction imposed on the Generalized Leontief and Translog functions, not required for the Cobb Douglas cost function, is the cross price restriction. This allows for symmetry of input combinations. Cross-price

restrictions are imposed on specification (4) and (5) when only one cross-product of each type is included into the model.

Continuity with respect to input prices holds to the first degree if the first derivative is not equal to zero. The property that the cost function is non-decreasing in w_{ijk} is evaluated using a derivative with the estimated function. The last property, concavity with respect to input prices, can be evaluated using the Hessian matrix. If the determinant of the matrix is negative semidefinite then the cost function is concave.

After estimating production for the solid wood and paper processing industries, misspecification testing is conducted again as in the factor demand case. If all assumptions hold, hypothesis testing can then be conducted on parameter estimates to determine the impact of each reform policy. This procedure follows McGuirk et al. (1993).

I assume that New Zealand's reforms are realized through shifts in the cost functions. That is, the specifications in (3), (4), and (5) will not include a lagged structure. This assumption is tested in two ways. First, using McGuirk et al. (1993) procedures showed that production was independent across time because of the aggregate data. Second, distributed lag models were estimated and showed the same result.[3b] In The Economist (1996), it is argued that the broad scope of privatization and deregulation reforms, and their swift implementation immediately after the 1984 election, completely surprised the forest sector. Further, policies were not phased in over time; rather, deregulation of price controls and sales of state-owned assets occurred

within a very short period of time after the reforms were announced. Consistent with these observations, dummy variables will be used in (3), (4), and (5) to identify and test shifts in total cost as a result of privatization and deregulation reforms.[3c]

Data to estimate (3), (4), and (5) come from published sources including the New Zealand Ministry of Forestry, Ministry of Commerce, and Statistics New Zealand. Appendix 3 reviews the data sources used in this study. The data consist of quarterly (seasonally unadjusted) time series with a total of 75 observations between 1977-1995. Some data transformations were necessary prior to estimation of (3), (4), and (5).

A. Estimation Results

Table 3A-3B present estimates of total cost functions for each industry and several functional forms. Each functional form specifies dummy variables depicting the removal of price controls in 1984 (D_1), removal of the log export ban in 1987 (D_3), and privatization reforms in 1990 (D_2). The estimates for all specifications could not be rejected for the presence of normality, linearity, homoskedasticity, parameter stability, non-autocorrelation.[3d] Likelihood ratio tests indicate response differences between industries.

A.1. Deregulation

[3b] See Appendix Table B1 & B2.
[3c] Chow tests were also used to verify the functional shifts we find with the dummy variables. The results are available form the author.
[3d] See Appendix Table A1 & A2 for results and description of methods used

Table 3A presents Cobb Douglas, Generalized Leontief, and Translog total cost function estimates for the wood industry form 1977-1995. Coefficients for output are significant at the 1% level and positive for the Cobb Douglas and Translog forms. The parameter estimates for raw material prices are significant and positive at the 1% levels across functional forms. The price of capital estimates are also significant and positive at the 1% level. These results are consistent with properties of total cost functions. The cost of labor is negative across functional forms, but is only significant for the Translog form. This is consistent with Evison's (1990) study showing a reduction in wood industry labor after deregulation. Coefficients for deregulation of price controls are only significant for the Generalized Leontief form and they are negative, suggesting that the wood industry's total cost function shifted downwards in response to deregulation. This response may have been caused by the reduction in production, shown in Chapter 2. The parameter estimate for the removal of the log is also significant for the Cobb Douglas and Generalized Leontief cases. The Cobb Douglas and Translog functional forms have a positive sign while the Generalized Leontief form has a negative sign. The positive sign is perhaps believable, and suggests that total costs were rising as production decreased. Evison's (1990) study supports this result. He identifies an influx of capital to the forest sector after 1987 (Figure 1C). This influx of capital may have been a result of investors viewing the wood industry as having a comparative advantage over other sectors.

Table 3B presents Cobb Douglas, Generalized Leontief, and Translog total cost function parameter estimates for the paper industry for 1977-1995. Coefficients for

material prices and labor prices are highly significant for the Cobb Douglas case and positive across forms.[3e] Coefficients for deregulation of price controls are significant and positive across functional forms, suggesting that total costs increased. This response corresponds to the paper industries increased production shown in Chapter 2. While production decreased for the wood industry, the paper industry was able to capture non-utilized fiber. The parameter estimates for the removal of the log export ban are significant and negative for the Cobb Douglas and Generalized functional forms, suggesting that total costs decreased. This response also corresponds to the industry's reduction in production shown in Chapter 2.

A.2. Privatization

Table 3A and 3B present coefficients for privatization dummy variables for each industry across functional forms. Coefficients for the wood industry are not significant at any level across functional forms. Although the coefficients are not significant, their negative sign suggests that total costs decreased because of lower production levels. This response may result from firms not securing a stable timber land base during the privatization process. Coefficients for the paper industry are significant at the 5% level and negative, suggesting that total costs decreased after privatization, and that lower management costs were incurred from newly acquired timber resources from the privatization process.

Deregulation and privatization affected total cost in the New Zealand wood and paper industries, however, the total cost response was greater for deregulation than for

[3e] These results are consistent with the assumed properties of total cost functions.

privatization. In the paper industry, deregulation of price controls increased cost by 0.12 using either the Cobb Douglas and Translog functional forms, while the wood industry showed decreased costs from these reforms. This increase in the paper industry resulted from higher raw material prices, increased competition for domestic wood supplies, and increased capital investment (Evison, 1990; Brown and Valentine, 1994). Only privatization (D_2) is significant for the paper industry using the Cobb Douglas and Generalized Leontief specifications. The signs are negative, suggesting that privatization decreased cost for the paper processing. This decrease resulted from private corporations purchasing government timber rights and securing wood supplies for meeting mill demands. Lifting the log export ban affected both the wood and paper industries (Figure 1D). For the wood industry, this reform showed contradictory results where the Cobb Douglas functional form showed an increase in costs and, the Generalized Leontief functional form showed a decrease in costs. For the paper industry, total costs decreased by 0.08 in the Cobb Douglas case and 0.10 in the Translog case. Overall, these results suggest that both industries probably experienced decreased costs after removing the log export ban. Privatization had a negative impact in the paper industry, but had no affect on the wood industry. The key result is that deregulation had a greater impact on total cost in the New Zealand forest manufacturing sector than did privatization. This is consistent with the findings in the previous chapter.

5. Model Extension

An extension of the analysis is to evaluate the impact of policy reforms on the rate of cost of diminution. As discussed earlier, the rate of cost diminution roughly anticipates the cost change induced by technical change. This corresponds to a shift in an industry's total cost function.

The rate of cost diminution is positive for both industries across functional forms. In the wood industry, the rate is positive and is not significant for the Cobb Douglas form. In the paper industry, the rate is positive across functional forms, but it is not significant for the Generalized Leontief specification.

The positive rates in this study, suggest that introducing new technologies pushed the total cost function upward. In other words, introducing new technologies increased total cost. This would seem to contradict Chamber's (1988) view that new technologies would diminish costs. This discrepancy can be explained by the existence of greater levels of capital investment in the wood and paper industries after deregulation and privatization. Table 3D & 3E show the mean increases in the value of capital investment for both industries in the periods before and after each policy reform. As both industries adjusted to a new economic environment with higher input prices and greater competition, investors viewed the sector as having a comparative advantage over other industries by increasing capital investments and reducing labor use. This occurred in the form of foreign ownership of domestic producers and the vertical integration of privatized public forests into corporate infrastructures. Costs increased because of the time required to get new technologies on line, and train skilled workers (Neilson and Smith, 1994).

Further evidence of these policy impacts are obtained comparing the coefficient changes between the deregulation and privatization dummy variables on the rate of cost diminution. In the wood and paper industries, deregulation and privatization generally depressed production because of higher input prices, fiber shortages, and integration costs of former public timberlands. The reduced production levels decreased total costs, but as capital investment increased, the introduction of new technologies increased total costs. These coefficients show the impact of deregulation and privatization being greater than the gains from technological improvement. This suggests that the short-run improvements from technical change could not offset the imposed deregulation and privatization shocks.

6. Concluding Remarks

In this chapter, I test the impacts of deregulation of price controls, removal of the log export ban, and privatization on total cost in the New Zealand forest sector. The purpose is to amass additional evidence that corresponds to the production shifts in the wood and paper industries for policy reforms in Chapter 1. The approach used to examine these impacts comes from estimating the total cost functions that incorporates dummy variables depicting each policy reform. The first reform policy that the New Zealand forest manufacturing sector experienced was the removal of price controls in 1984. The results across total cost models give mixed responses regarding this reform on New Zealand's forest industries. After the removal of price controls, total costs decreased in the wood industry, while total costs increased in the paper industry. In the

wood industry, part of the total cost decrease was due to production decreases which shifted the industry's aggregate supply function backwards. However, in the paper industry, total cost increased as production increased which shifted the industry's aggregate supply function outwards (e.g., see Chapter 2).

The second reform policy that the New Zealand forest manufacturing sector experienced was the removal of the log export ban in 1987. This corresponded to the elimination of the New Zealand Forest Service and creation of the New Zealand Forestry Corporation. The implementation of this reform policy increased total cost in the wood industry and decreased it in the paper industry. When the log export ban was removed, private timberland owners and the New Zealand Forestry Corporation sold their logs to the highest bidder. International wood buyers such as the Australians, Japanese, Chinese, and Koreans out-competed domestic producers for fiber supplies. In addition, the New Zealand economy was experiencing policy induced recession that dampened domestic demand for wood and paper products. These events created a input constraint that caused lower levels of production for both the wood and paper processing industries (Figure 1E). This reduction in wood industry production and resulting shift backwards of the aggregate supply function decreased total costs, but new capital investment in the sector apparently increased total costs by a greater amount. Total costs in the paper industry decreased because of lower production levels, imposed by the shortage of available raw material. The wood industry total cost schedule was more adversely affected than the total cost schedule for the paper industry.

The last reform policy that the New Zealand forest manufacturing sector experienced was the start of privatization reforms, in 1990. The aim of privatization was to sell long-term management rights of timberlands and mills to private entrepreneurs. Privatization did not have a significant impact on total cost in the wood industry, but it had a significant impact in the paper industry. After privatization, total cost in the paper industry decreased, because of the lower transaction costs of getting raw material to mills, and the completion of technological improvements induced by high domestic interest rates (Bilek and Horgan, 1992).

The key result from this study is that deregulation had a greater impact on total costs in the New Zealand forest manufacturing sector than did privatization. Changes in total costs were dependent on changes in production and supply, but capital investment had a greater impact. This was particularly true for the New Zealand wood processing industry. Of the deregulation policies, the removal of the log export ban had a greater impact on total cost than did the removal of price controls for the wood industry. In the paper industry, deregulation of price controls had a greater impact on total cost than the removal of the log export ban. The different response between industries suggests that the wood industry was more vulnerable to international competition, but the paper industry was more sensitive to price controls.

The contribution this chapter offers is its comparative analysis of how deregulation and privatization affected the New Zealand forest manufacturing sector using an econometric approach. This study specifically focuses on the impacts of these policy events on cost functions, and rate of cost diminution. At present, there is no

econometric study I am aware of that addresses the impacts of these policy reforms jointly on the forest sector in New Zealand or elsewhere.

The results from this study have many possible applications to other countries such as Australia, Canada and the United States who are considering the implications for privatizing publicly owed forest assets. Australia is probably further along this route than the other countries. Hall's (1997) study suggests keeping in mind the special conditions in New Zealand such as an extensive exotic plantations and history of government production enterprises before implementing privatization reform. Hall concludes that, for the United States, privatization programs should be limited to some National forest lands where wood production is the emphasis. In addition, Hall suggests that reform proceed slowly and cautiously incorporating a trial and error period to develop appropriate procedures before mass implementation. Hall's conclusion and the results of this study suggest the possibility of implementing privatization in a limited sense to forest sectors outside New Zealand.

Privatization also had surprising results. It had no significant impact on the wood and paper production functions, however, the paper industry's total cost function decreased. This perhaps resulted from the lower transaction costs from getting wood from newly acquired forest lands to the mills. In addition, outsourcing became a major source of reducing labor costs by many firms in other countries. In New Zealand it has become a popular option, and clearly it has contributed to the backward shift of the aggregate cost function for the paper processing industry.

Future research in studying the impacts of deregulation and privatization is needed, not only for New Zealand, but for other countries considering the implementation of these programs. An extension of this analysis for New Zealand is to consider using the user cost of capital instead of nominal rates of return. In addition, one should obtain firm level panel data for those corporations that existed before and after each policy, and use this to examine the impacts of these policy events in more detail.

Table 3A: Parameter Estimates for Total Cost Functions in the New Zealand Wood Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	1.29*	-184.46	-2156.1***
	(0.75)	(171.1)	(305.0)
Y (Export Wood Volume)	1.02***	--	402.83***
	(0.10)		(48.77)
Y^2	--	--	-18.73***
			(1.92)
W_1 (Price of Raw Materials)	0.52***	--	204.08***
	(0.05)		(47.20)
W_2 (Price of Capital)	0.49***	--	646.94***
	(0.07)		(57.82)
W_3 (Price of Labor)	-0.06	--	-725.15***
	(0.10)		(78.28)
W_{11}	--	0.79	-13.12***
		(1.03)	(3.87)
W_{22}	--	1.47	-20.41***
		(21.48)	(7.42)
W_{33}	--	-4.22	-63.81***
		(41.40)	(12.10)
W_{12}	--	-5.16	-32.12***
		(6.26)	(3.20)
W_{13}	--	0.86	38.79***
		(8.73)	(3.54)
W_{23}	--	40.52	41.21***
		(0.48)	(0.05)
YW_1	--	--	-17.60***
			(3.93)
YW_2	--	--	-67.17***
			(6.52)
YW_3	--	--	72.15***
			(9.42)
D_1 (Deregulation of Price Controls)	-0.06	-60.56**	-1.59
	(0.04)	(28.45)	(1.01)
D_2 (Removal of Log Export Ban)	-0.07	-16.64	1.19
	(0.04)	(32.69)	(1.32)
D_3 (Privatization)	0.15***	-84.22*	1.08
	(0.05)	(51.01)	(1.34)
T (Cost of Diminution)	$0.7x10^{-3}$	5.52***	0.14**
	($0.2x10^{-2}$)	(1.82)	(0.07)

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels. Parenthesis is standard error.

Table 3B: Parameter Estimates for Total Cost Functions in the New Zealand Paper Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	11.12***	396.75***	-27.63
	(0.46)	(113.8)	(33.06)
Y (Export Paper Product Volume)	-0.33***	--	5.87
	(0.06)		(6.57)
Y^2	--	--	0.08
			(0.36)
W_1 (Price of Raw Materials)	0.40***	--	9.66
	(0.07)		(7.35)
W_2 (Price of Capital)	$0.3x10^{-2}$	--	-8.12**
	(0.06)		(3.98)
W_3 (Price of Labor)	0.50***	--	0.94
	(0.08)		(4.56)
W_{11}	--	1.38	0.20
		(1.21)	(0.94)
W_{22}	--	18.94	-0.88
		(41.72)	(0.84)
W_{33}	--	6.72	-0.18
		(33.92)	(0.43)
W_{12}	--	-12.65	0.19
		(13.05)	(0.72)
W_{13}	--	-7.06	-0.61
		(10.76)	(0.44)
W_{23}	--	77.04	0.86**
		(52.41)	(0.38)
YW_1	--	--	-1.67**
			(0.73)
YW_2	--	--	1.27***
			(0.47)
YW_3	--	--	0.28
			(0.59)
D_1 (Deregulation of Price Controls)	0.12***	84.33***	0.12***
	(0.03)	(23.03)	(0.03)
D_2 (Removal of the Log Export Ban)	-0.07**	-81.47***	0.03
	(0.03)	(23.32)	(0.04)
D_3 (Privatization)	-0.08**	42.07	-0.10**
	(0.04)	(26.37)	(0.04)
T (Cost of Diminution)	$0.5x10^{-2}$***	0.73	$0.6x10^{-2}$***
	($0.1x10^{-2}$)	(1.24)	($0.2x10^{-2}$)

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels. Parenthesis is standard error.

Table 3C: Likelihood Ratio Test for Total Cost Functions in the New Zealand Wood and Paper Industries

Wood Time	Paper Time	χ^2 Test Statistic	Functional Form	Approach
77-84	77-84	19.82	Cobb Douglas	cost
84-95	84-95	16.06	Cobb Douglas	cost
77-90	77-90	32.10	Cobb Douglas	cost
90-95	90-95	-1.74	Cobb Douglas	cost
77-87	77-87	36.00	Cobb Douglas	cost
87-95	87-95	7.47	Cobb Douglas	cost
77-84	77-84	15.00	Generalized Leontief	cost
84-95	84-95	-18.82	Generalized Leontief	cost
77-90	77-90	-29.96	Generalized Leontief	cost
90-95	90-95	14.81	Generalized Leontief	cost
77-87	77-87	10.40	Generalized Leontief	cost
87-95	87-95	10.19	Generalized Leontief	cost
77-84	77-84	38.42	Translog	cost
84-95	84-95	180.44***	Translog	cost
77-87	77-87	80.08***	Translog	cost
87-95	87-95	138.18***	Translog	cost

Note: numbers in the above table were rounded to two significant digits after calculating the test statistic, therefore readers calculating the test statistic using the above numbers may find small discrepancies due to rounding by the author. * significant at the 10%; ** significant at 10% and 5% levels; *** significant at 10%, 5%, and 1% levels.

Table 3D: Percentage Change in Wood Industry Inputs (Mean Values) Before and After Reform Policy Implementation

Inputs	Percent Change After Removal of Price Controls	Percent Change After Removal of the Log Export Ban	Percent Change After Privatization
Raw Material	55.34%	44.13%	56.13%
Capital	372.41%	134.69%	103.32%
Labor	-10%	-10.7%	-3.5%

Table 3E: Percentage Change in New Zealand Paper Industry Inputs (Mean Values) Before and After Reform Policy Implementation

Inputs	Percent Change After Removal of Price Controls	Percent Change After Removal of the Log Export Ban	Percent Change After Privatization
Raw Material	112%	59%	39%
Capital	174%	84%	23%
Labor	1.7%	-8.8%	-11%

7. Appendix 3: Description of Data used in Chapter 3

The data used in estimating the Cobb-Douglas, Generalized Leontief, and Translog cost models for both the New Zealand wood and paper industry came from three sources. They are the New Zealand Ministry of Forestry and New Zealand Ministry of Commerce. Energy use data for both the wood and paper industries came from the Ministry of Commerce. The price of capital used in this study came from Statistics New Zealand. All other data used in this chapter came from the NZ Ministry of Forestry.

Data was available as quarterly or annual time series from 1977-95 as outlined in Appendix Table 2A1 below. The final number of observations for model estimation is 75. Annual data were linearized into quarters to provide a greater number of observations. Data that was linearized included export wood and paper volumes (Y), and price of capital (W_2). The price of capital is nominal in nature, thus no corrections have been made for inflation. Total cost data (TC) is calculated by summing the values of raw material stocks, additions to fixed assets, salaries & wages, and purchase and other operating expenses.

Obtaining input prices for the price of raw materials and price of energy required simple calculations. In the wood industry, the price of raw materials (W_1) was obtained by dividing the value of raw materials by logs and poles inputs. In the paper industry, the price of raw materials (W_1) was obtained by dividing the value of raw materials by volume of wood chip inputs. For both industries, the price of labor (W_3) is calculated by

dividing hours worked by salaries and wages. For both industries the value, the price of energy use (W_4) is calculated by dividing the value of petroleum products by energy use.

Appendix Table 3A: Data Description of Total Cost Functions in the New Zealand Wood and Paper Industries

Variable Symbol	*Variable*	*Data*	*Time*	*Type*	*Source*
Wood Processing Industry					
TC	Total cost	Stocks of materials, additions to fixed assets, salaries & wages, and purchase and other operating expenses	1975-95	Quarterly	Statistics New Zealand and NZ Ministry of Forestry
Y	Export Wood Volume	Total panel, log, and sawn timber exports	1977-1995	Annual	NZ Ministry of Forestry
W_1	Price of Raw Materials	Stocks of raw materials, log and poles inputs	1977-1995	Annual and Quarterly	NZ Ministry of Forestry
W_2	Price of Capital	Rate of return	1976-1995	Annual	Statistics New Zealand
W_3	Price of Labor	Hours worked, salaries & wages	1977-1995	Quarterly	NZ Ministry of Forestry
W_4	Price of energy use	Value of petroleum products, quantity of energy use	1976-1995	Quarterly and Annual	Statistics New Zealand, NZ Ministry of Commerce
D_1	Deregulation of price controls	Dummy variable 0's until 1984, then 1's afterwards	--	--	--
D_2	Removal of the log export ban	Dummy variable 0's until 1987, then 1's afterwards	--	--	--
D_3	Privatization	Dummy variable 0's until 1987, then 1's afterwards	--	--	--
T	Cost of diminution	Time trend	--	--	--

Appendix Table 3B: Data Description of Total Cost Functions in the New Zealand Paper Industries

Paper Processing Industry					
TC	Total cost	Summation of stocks of materials, additions to fixed assets, salaries & wages, and purchase & other operating expenses	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
Y	Export Paper Volume	Total paper and paperboard exports	1977-1995	Annual	Statistics New Zealand, NZ Ministry of Forestry
W_1	Price of Raw Material	Stocks of raw materials, wood chip inputs	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
W_2	Price of Capital	Rate of return	1976-1995	Annual	Statistics New Zealand
W_3	Price of Labor	Hours worked, salaries & wages	1977-1995	Quarterly	Statistics New Zealand, NZ Ministry of Forestry
W_4	Price of Energy	Value of petroleum products, quantity of energy use	1976-1995	Quarterly & Annual	Statistics New Zealand
D_1	Deregulation of price controls	Dummy variable 0's until 1984, then 1's afterwards	--	--	--
D_2	Removal of the log export ban	Dummy variable 0's until 1987, then 1's afterwards	--	--	--
D_3	Privatization	Dummy variable 0's until 1987, then 1's afterwards	--	--	--
T	Cost of diminution	Time trend	--	--	--

Chapter 4

Policy impacts on cost efficiency in the New Zealand wood industry

Introduction

Tradeoffs between developing international competitiveness through exploitation of forest capital, and providing public goods from the forest have always been difficult compromises for governments throughout the world. These tradeoffs are especially apparent whenever natural resource ownership is privatized, natural resource based industries are deregulated, or protection-oriented economies with large forest bases are opened. Deregulation and removal of trade restrictions are common, yet few countries have privatized their forest resources. Exceptions are Chile, Eastern Europe, and New Zealand. Chile has undergone institutional reform aimed at reducing government intervention through deregulation (Lüders, 1991). New Zealand is perhaps the most progressive case, implementing extensive restructuring as part of an effort to open its traditionally closed, protectionist economy (Bilek and Horgan, 1992). New Zealand's reforms, like those in Eastern Europe, have involved large-scale sales of state-controlled assets to private investors.

New Zealand's radical economic reforms began with the 1984 national election, when poor macroeconomic conditions prevailed.[4a] The country had been experiencing poor productivity and growth, overly restrictive industrial regulations, a history of failed governmental stabilization polices, and devaluation of the New Zealand dollar (Duncan and Bollard, 1992). New Zealand's broad-based reform programs were intended to increase efficiency, reduce public intervention, and promote increased competition in the private sector.

Two types of reforms targeted the forest sector. The private sector was deregulated, while the public sector was privatized. Specific deregulation reforms included removal of wood export bans, and removal of all price controls on exports of state-owned wood, both of which resulted in wood prices rising to world levels within a short period of time (Birchfield and Grant, 1993). Privatization reforms included eliminating the New Zealand Forest Service, and corporatizing the management of state-owned public capital and land resources within the country. Since these reforms the forest sector has grown into one of the country's top primary export sectors and a major Pacific rim supplier, contributing 9% of total New Zealand exports in 1991 (Chatterjee, 1992).

Despite that New Zealand has become an important international wood supplier, little is known about the impact of its reforms on the forest industry, or the speed with which adjustments occurred. The purpose of this paper is to examine the impacts of

[4a] For example, the current account balance was over 8%, the governmental fiscal balance had a deficit of over 6%, and net public debt was 40% of GDP (Evans et al., 1996).

deregulation and privatization on cost efficiency in the New Zealand wood processing industry. Cost efficiency will be computed by estimating stochastic cost frontiers where the error term is comprised of an efficiency component (e.g., Aigner et al., 1977; Bauer, 1990; Greene, 1993). This approach allows us to study several new questions related to New Zealand policy reforms, such as i) were there significant changes in cost efficiency of the wood processing industry as a result of the reforms, and ii) which policy reform, deregulation or privatization, had a larger impact on the forest sector and on New Zealand's competitiveness as an international wood supplier?

My results provide some general insight into the short run effects of privatization and deregulation, in a country where the forest sector is a significant part of the economy. In particular, I show that capital-intensive industries with comparative advantages, such as New Zealand's wood sector, may suffer efficiency losses in the short run as the economy adjusts toward increased production in those sectors. While the expansion of New Zealand's exports has led many to believe that privatization and deregulation have improved efficiency, reduced domestic interest rates after deregulation led to an infusion of capital and increased capital-labor substitution once reforms occurred. This was aided by the reform of capital controls allowing international investors to own a stake in domestic corporations. Much of the capital-labor substitution resulted through investment of new technologies, which have required time to operate at maximum efficiency (Neilson and Smith, 1994). Thus, the ultimate success of deregulation and privatization will depend on how quickly these technologies can be

used to exploit New Zealand's comparative advantage in the world wood market. This in turn depends on the speed at which capital-labor substitution occurs.

Privatization and deregulation have been studied historically in the economics literature.[4b] However, efficiency gains from deregulation and privatization have not been investigated for the forest sector. Several studies have focused on estimating technical efficiency. Recent examples are work by Harris (1993), Carter and Cubbage (1994), and Carter and Cubbage (1996). Harris examined technical efficiency for New Zealand manufacturing industries and several sub-sectors, two of which were the wood and paper processing industries. He used a stochastic frontier approach with cross-sectional data to measure technical efficiency, however, technical efficiency was computed only for a single period after deregulation began. Carter and Cubbage (1994) estimated technical efficiency for firms in the Southern U.S. forest industry using the method of covariation. Their purpose was to identify harvest methods that are most cost efficient. Carter and Cubbage (1996) used a stochastic frontier approach, based on estimating a production function at two points in time, to compute mean technical inefficiency of logging firms in the Southern U.S. Our approach differs in that I rely on estimating cost functions, which do not suffer the potential endogeneity problems that production functions may, and I use time series data to estimate shifts in efficiency over time induced by policy reforms for the wood industry.

[4b] Since the early 1980s privatization programs of nonforest-based industries have been implemented throughout the world, including the America's, United Kingdom, Mexico, Chile, Japan, New Zealand, and most recently Eastern Europe (Karscig, 1990; Lüders, 1991; Haskel and Szymanski, 1993). The basic

The remainder of the paper is organized as follows. Section 1 summarizes the timing of New Zealand's public and private policy reforms. Section 2 presents the stochastic frontier model, and I show how it can be used to estimate cost functions and determine "mean cost inefficiency." Section 3 presents results from applying the stochastic frontier model to New Zealand wood industry data, and estimates changes in cost efficiency induced by privatization and deregulation. Finally, Section offers conclusions and policy implications.

2. New Zealand's Deregulation and Privatization Experience

The New Zealand Forest Service was established in 1919 with the purpose of managing existing forests and preventing local wood shortfalls. Radiata pine was selected as the primary species for reforestation. By the 1980's, reforestation on state land and incentives for planting on private lands led to a production forest area base of 1.1 million acres, of which 47.3% was owned by the National government. This forest base represented a significant portion of the country's total asset portfolio (Bilek and Horgan, 1992).

Prior to the 1984 national election, the New Zealand Forest Service had several issues with which to contend. Most importantly, the agency was required to compensate for high country-wide unemployment through forced hiring of unskilled labor (Birchfield and Grant, 1993). The agency was also involved in administering costly reforestation

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reasons cited for privatization reforms are to increase profitability, capital intensity, and operating efficiency of firms, or to alleviate federal budgetary deficits (Megginson et al., 1994).

incentive programs on private lands. Price controls were extensive, and domestic wood prices were well below world levels. A ban on exports of public-harvested wood, and increasing opposition to harvesting of native forests, also existed.

The 1984 election began a sequence of policy revisions that would forever change the nature of New Zealand's forest sector. All price controls were removed at once in 1984. In 1987, the public log export ban was lifted, and the Forest Service was transformed into the "Forestry Corporation." Prior to its removal, the log export ban had provided considerable incentives for private wood suppliers to sell to foreign buyers.[4c] In 1989, the Corporation announced intentions to sell all State commercial forest assets beginning in 1990. In the first year, nearly half of the public forest land assets had been sold to private concerns, and by 1992, the government's ownership of forest land had decreased to only 17.5% (Turland, 1990; Brown and Valentine, 1994). The Forestry Corporation was dismantled in 1997.

The reforms and subsequent changes to the Forest Service created major adjustments within the forest sector. During the periods of deregulation between 1986 to 1989, total roundwood removals from New Zealand forests increased from 10.2 million m^3 to 11.7 million m^3, a 15% increase, while total exports of forestry products increased 113%. After 1990, removals increased by 40% because of maturity of plantation resources and higher international prices stimulated by the spotted owl situation in the

[4c] The adjustments in domestic prices that occurred with deregulation and the log ban removal were substantial. In fact, the increase in domestic wood prices between 1986 and 1987 was enough to completely remove the NZ $71 million budget deficit of the Forestry Corporation (Birchfield and Grant, 1993).

United States pacific northwest. In addition, high interest rates at the beginning of policy reforms encouraged development of new technologies using foreign moneys and capital. Examples of these technologies included new preservative wood treatments, green finger joining, vapor boom treatments, and wood hardening processes (Butcher, 1991). Labor productivity increased 23%, accompanying a 29% drop in total employment within the wood industry (Evison, 1990). Privatization of the public forest base also induced major ownership adjustments—Firms such as Carter Holt Harvey and Fletcher Challenge increased their holdings of forest plantation acreage to roughly 26% and 15% respectively. Over 100 new wood industry mills were established between 1990 and 1995 to accommodate increased demand (NEFD, 1995).

3. Stochastic Cost Frontier Specification

Deregulation, removal of the log export ban, and privatization all potentially affect the efficiency of the forest industry. Cost efficiency is essentially the distance of a total cost observation from a cost frontier (Figures 1H & 1I). In other words, an observation is cost inefficient when the monetary expense needed to produce a given output level is not the lowest. There are two methods proposed in the economics literature to estimate efficiency. The first is by Farrell (1957). In his classic paper, the distance between an individual firm's output and the aggregate production frontier surface is defined as efficiency. However, Farrell's approach is non-stochastic. The second approach relaxes this assumption to allow an econometric estimate of efficiency (Aigner et al.,1977; Meeusen and van den Broeck, 1977; Schmidt and Lovell, 1979,

1980). The primary advantage in using the stochastic frontier approach is that it accommodates white noise error variation (Schmidt, 1986).

The stochastic frontier approach has recently been extended to accommodate cost functions. Cost functions are not likely to suffer from endogeneity present in estimating production functions (Bauer, 1990; Greene, 1993). Under the cost function approach, efficiency is essentially measured as the total costs incurred from a set of inputs used to produce a given output. Following Bauer, I define the cost function as

$$C_i = f\left(w_{ij}, d_g, t, \varepsilon_i; \Gamma\right), \qquad (1)$$

where C_i is a total cost vector for observation i, w_{ij} is a vector of input prices for observation i and input j, Γ is a vector of parameters to estimate, ε_i is an error vector, d_g is a dummy variable describing various policy events, and t is a time trend. The error term, ε_i, consists of two independent components v_i and u_i such that $\varepsilon_i = v_i + u_i$. $v_i \sim N\left(0, \sigma_v^2\right)$ is a two-sided error term explaining statistical white noise with a standard deviation of σ_v. $u_i \geq 0$ is a one-sided error term explaining cost efficiency (for details, see Aigner et al., 1977).

Mean cost inefficiency (MTI) can be computed from the mean of the distribution of u_i (Aigner et al., 1977). As is common, in the case where u_i is distributed as a half-normal random variable, $N\left(0, \sigma_u^2\right)$, the MTI equals $\sigma_u \sqrt{(2/\pi)}$ (Jondrow et al., 1982).[4d]

[4d] Historically, technical efficiency has been measured for each observation, where each observation represented an individual firm. However, in this study the interest is in determining how efficiency has changed over time in response to policy reforms; Thus we are interested in estimating technical efficiency for the other industry at each point in time. This approach is similar to the one in Harris (1993), who uses a production function model to estimate MTI using aggregate data for several industries.

Thus, estimating MTI requires obtaining an estimate of σ_u, the standard error of u_i. Details of this estimation are provided in Appendix 4.

4. Empirical Model

To study how efficiency changed in response to privatization and deregulation reforms, I must first estimate cost functions for New Zealand's wood industry during the important reform periods. To facilitate comparisons, Cobb Douglas and Translog specifications will be used (e.g., see Chung, 1994). Each of these must be transformed prior to estimation in order to satisfy the homogeneity and symmetry properties required of cost functions (Varian, 1992). The transformed Cobb Douglas cost function is given by,

$$LnC_i = \ln\zeta + \sum_i \phi_j \ln w_{ij} + \ln y_i + d_g + t + \eta_i \qquad (2)$$

where LnC_i is the log-transformed cost of producing y_i for observation i, ϕ_j is the coefficient of input w_j, t is the trend, d_g is dummy variable for policy reforms, η_i is error term, and ζ equals the constant. The Translog specification is given by (e.g., see Chung, 1994),

$$\ln C_i = \ln\alpha + \delta \ln y_i + \sum_j \beta_j \ln w_{ij} + \frac{1}{2}\gamma\left(\ln y_i\right)^2 + \frac{1}{2}\sum_j\sum_k \beta_{jk} \ln w_{ij} \ln w_{ik} + d_g + t + \eta_i \quad \forall i. \qquad (3)$$

where α, δ, β_j, γ and β_{jk} are parameters to estimate, j=1,…,m, k=1,…,m, and all other variables are previously defined. One restriction imposed on the Translog cost function, not required of the Cobb Douglas specification, is a cross price restriction which allows for symmetry of input use with respect to prices.

I assume that New Zealand's reforms are realized through shifts in the cost functions. That is, the specifications in (2) and (3) will not include a lagged structure. Although I test this assumption later, the rationale is found in the history of the reforms.[4e] In The Economist (1996), it is argued that the broad scope of privatization and deregulation reforms, and their swift implementation immediately after the 1984 election, completely surprised the forest sector. Further, policies were not phased in over time; rather, deregulation of price controls and sales of state-owned assets occurred within a very short period of time (less than a year) after the reforms were announced. Consistent with these observations, dummy variables will be used in (2) and (3) to identify and test shifts in total cost as a result of privatization and deregulation reforms.[4f]

Data to estimate (2) and (3) come from published sources including the New Zealand Ministry of Forestry, Ministry of Commerce, and Statistics New Zealand. Appendix 3 reviews the data sources used in this study. The data consists of quarterly (seasonally unadjusted) time series with a total of 75 observations between 1977-1995. Some data transformations were necessary prior to estimation of (2) and (3). For output volume, only annual data was available, so linear interpolations were used. Given the importance of exports in the New Zealand forest sector and the relatively small scale of domestic consumption, export volume was used for industry output (although this proxy is less of a concern for the cost approach used here). Raw material input prices were

[4e] For example, the model will run ex post with lagged dependent and independent variables to determine whether a lagged structure fits the data. In this study, we suspect a lagged structure will not work well given the aggregate industry data used.

derived by dividing the value of material stocks by the volume of raw material input. Finally, total costs were defined by adding the value of materials, fixed assets, salaries and wages, purchases, and other operating expenses for each quarter.

A. Estimation Results

Tables 4A-4B present estimates of the stochastic frontier cost functions for several relevant time periods and each functional form.[4g] These periods represent New Zealand's reform history: 1977-84 (pre-deregulation), 1984-95 (post-deregulation), 1977-90 (pre-privatization), and 1990-95 (post-privatization). The estimates for both specifications could not be rejected for the presence of normality, linearity, homoskedasticity, parameter stability, and non-autocorrelation.[4h] An F-test indicates that the Translog functional form best represented the data, however, to preserve degrees of freedom and overcome convergence problems with the Translog specification, both functional forms were used to analyze policy impacts.[4i]

A.1. Deregulation

[4f] Chow tests were also used to verify the functional shifts we find with the dummy variables. The results are available form the authors.

[4g] In this paper, we estimate cost functions for different periods, rather than only the sample period 1977-95, because we are interested in testing structural changes in efficiency that have occurred in the different periods. Moreover, estimation for the entire period would not converge for the stochastic frontier models, indicating that these reforms were significant enough to make the assumption of a single technical efficiency measure over all periods unrealistic. The assumption that these reforms shifted the cost functions within the forest industry is supported by the known influx of capital and new technologies that accompanied the reforms, and the fact that the industry was surprised by each policy change (The Economist, 1996).

[4h] The results of these tests are available form the authors upon request.

[4i] Degrees of freedom were too small to use the Translog function for the post-privatization period (1990-95). See Appendix Table C1 for F-test results.

Table 4A presents Cobb Douglas and Translog cost function estimates for the wood industry during pre- and post- deregulation periods. Referring to the post-deregulation period, the variables D_1 and D_2 represent dummy variables for deregulation of price controls in 1984 and privatization in 1990, respectively. Coefficient for raw material input prices (W_1) are significant and positive in both cases, while coefficients for other inputs are generally insignificant. This is consistent with the earlier observation that, prior to deregulation, raw material was most important in the production of wood given the low labor total labor productivity that existed for New Zealand. In both cases the industry output variable has the predicted positive effect on total cost. Industry output is more important to the cost function in the post-reform period. This is evidence of production expansion that occurred in existing plants (and the resulting increased cost) within the short run reform period, before new mills and technologies contributed significantly to production.[4j] It is also evidence that the New Zealand wood sector has not yet exploited any potential returns to scale that should accompany the increased capital investments which followed deregulation (Figure 1E).[4k]

Comparing estimates for pre- and post-deregulation gives insight into the relative effects of reform. Turning to the policy dummy variables in the post-deregulation period, the most important impact on total costs occurred with the removal of the log export ban, measured by the coefficient of D_3. Its positive sign is consistent with

[4j] Estimated factor demands for the pre- and post-deregulation also provide evidence of the impact that capital investment had on factor usage in the wood industry.

changes that accompanied removal of the ban. The New Zealand forest sector at the time of the ban was not expecting a reduction in protectionism, and there were several obsolete and inefficient mills (Tapsell, 1989; Evison, 1990). As deregulation opened the economy, the comparative advantage of the forest industry provided an incentive to update these mills and increase their presence in the world market. However, this required high fixed-cost capital investments, which occurred in the form of new mills and new technologies such as advanced bleaching and inventory management. Thus, the increase in scale has not been immediate, and expanded production at existing mills, combined with the steep learning curve of new technologies has led to increased total costs within the industry.[4l] This is also consistent with the strong and significant sign on capital price (W_2) in the post deregulation period for the Cobb Douglas specification. Later I will show how this response is relevant to cost efficiency changes within the wood sector.

The Translog estimates are similar to the Cobb Douglas estimates and are consistent with changes in the capital market that accompanied deregulation.[4m] Raw material price (W_1) is significant at the 0.01 level and positive, contributing 24.42% less to total cost in the post-deregulation period relative to pre-deregulation. Although labor

[4k] Moreover, note that output is significant in the post-deregulation period despite that some other input prices are not. This is consistent with the observation that deregulation led to appreciation in raw material and labor prices to higher world levels (e.g., Duncan and Bollard, 1992).

[4l] A cost function was estimated using a lagged dependent variable regressor to test whether adjustments to cost occurred over time between the policy reforms. Several lag lengths were tried. However, in all of these regressions the coefficient on the lagged variables were negative and insignificant. Although it is insignificant, this negative sign would be an indication that costs are decreasing over time as the industry becomes more adept at using the new technologies, and as new plants begin to operate at optimal levels.

and capital prices are not significant at any level, they contributed 102.26% and 19.64% less to total cost respectively after reform policy implementation. These observations are again consistent with the influx of capital that occurred in response to deregulation. For example, as capital investment from international sources increased, the price of capital decreased, thus decreasing its contribution to total wood industry costs.

A.2. Privatization

Table 4B presents estimates of the Cobb Douglas cost function for pre- and post-privatization periods. Unlike deregulation, which represented mainly removal of price controls, the major impact from privatization was to change the availability of wood supplies from government forests. Seven of the eight parameter estimates for the wood industry's 1977-90 time series model are significant at the 10% level, of which two are significant at the 5% level and five at the 1% levels. Similar to the regressions above, input prices are all positive and significant except for labor in the post-deregulation period, which is insignificant.[4n]

The results show that the most important impact from privatization comes from raw material use, which contributed 300% more to costs after privatization than before. This is in part due to the increased use of government wood as a low cost source. However, the results also demonstrate that privatization had less to do with adjustments toward exploiting the comparative advantage of the wood industry than did deregulation.

[4m] Referring to Table1, output is significant in the Translog specification for both pre- and post-deregulation periods.

This is suggested by the substantially smaller coefficient estimated for the privatization dummy (D_2) in the regression compared to those for deregulation and log ban removal. However, both the removal of the log export ban (D_3) and deregulation of price controls (D_1) show similar affects on total costs. This is again most likely due to expansion of production at existing plants in the short run (and an associated movement upward on the marginal cost curve), as new technologies and mills were developed and implemented.

B. Cost Efficiency

The above results establish how reforms were crucial in encouraging outside investment into the forest sector, allowing the New Zealand economy to exploit the comparative advantage it has in growing wood. Computing mean cost inefficiencies for the wood industry before and after each policy reform will add additional insight into which reforms provided the greatest incentives for investment and innovation within the wood industry. I am also interested in whether the short run affects of these reforms have led to increased or decreased efficiency.

Recall that cost efficiency in stochastic frontier models is roughly defined as the total cost associated with a set of inputs. The lower the total cost for a given output, the lower is the mean cost inefficiency (Figures 1H & 1I). Table 4C presents the mean cost inefficiency computed for the Cobb Douglas and Translog stochastic frontier cost

[4n] A negative sign for labor is possible if new capital investment caused increased substitution of capital for labor. This would have increased the quality of existing labor, which in turn could have decreased the

functions and the reform periods.[4o] The Translog functional form was used for the deregulation and log ban removal reforms. However, for privatization where the degrees of freedom prevented reliable estimation of a Translog specification, I present mean cost inefficiency based on the Cobb Douglas specification.

The results show that all reforms have led to *decreased* cost efficiency within the wood industry, at least for the sample period through 1995. The largest decrease was due to the removal of export bans for government harvested wood, which increased mean cost inefficiency by over 300%. Mean cost inefficiency also increased substantially under deregulation and privatization.

Table 4D provides some intuition for these results. As discussed earlier, New Zealand's policy reforms were responsible for a large capital influx into the country, with the log export ban responsible for the largest increases in capital investments over the sample period (Figure 1C). Expanded opportunities to export government wood encouraged entry into the forest sector from foreign firms (Duncan and Bollard, 1992). It also encouraged increased production within existing plants, which increased costs (Neilson and Smith, 1994). Our results suggest cost efficiency decreased during this time of rapid capital investment, since the investment occurred in form of newer technologies that required some time to bring on line and operate at maximum efficiency

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marginal cost of labor.

[4o] The significance of the parameter $\sigma_v + \sigma_u$ indicates that the stochastic frontier method is statistically valid, and that the estimates of technical efficiency are consistent and efficient.

(O'Loughlin, 1990; Brown and Valentine, 1994) (Figures 1E & 1I).[4p] New investments may also have imposed adjustment costs onto the wood industry in the form of changes in capital-labor substitution required to exploit the newer technologies. These adjustment costs could also have contributed to reduced efficiency.

Other work supports these findings. Evison's (1990) study of New Zealand's wood industry indicates that output did not increase substantially despite significant increases in capital investments during the post-log ban removal period.[4q] His evidence also demonstrates an increase in labor productivity after 1984, when price controls were removed. Referring to Table 4D, hours worked in the wood industry decreased by 9.96% after the removal of price controls. Both of these observations are an indication of the substitution for labor that was occurring during the reform period. For similar reasons, cost inefficiency increased in the short run with privatization and deregulation. For example, referring to Table 4D, although hours worked decreased by 3.5% after 1990 (the year of privatization), mean capital investment increased by 103%, and output production was not significantly higher in the post reform period.

Aside from capital influx, the changing structure of the forest industry may have also contributed to short term efficiency losses in the post-reform periods (Figure 1I). Prior to reforms, the industry consisted of small outdated mills that remained operational through protectionist macroeconomic policies (Tapsell, 1989). Removal of price

[4p] Factor demand equations for capital were also estimated for the Translog functional form using dummy variables to identify policy reforms. The dummy variable for price control reform was positive and significant, suggesting an increase in capital use for this period. This observation supports the above Translog result.

controls increased input prices, causing industry owners to invest in input-saving technologies to deal with higher input prices (Bilek and Horgan, 1992). Moreover, removal of the log export ban provided an incentive for foreign timber interests to purchase government land and wood. As a result of these changes, domestic wood suppliers, who have been documented as inefficient prior to reforms (e.g., Evison, 1990), could not afford to pay the high post-reform stumpage prices required to supply their mills. The resulting raw material constraint increased the need to substitute other factors of production to expand and take advantage of increased export possibilities. This short run expansion may have contributed to efficiency losses.[4r 4s]

5. Concluding Remarks

In this paper I have examined the impacts of deregulation and privatization on costs within the New Zealand wood industry. Our goal was to determine how these reforms affected cost efficiency. This is an important issue throughout the world, as governments debate the merits of privatizing natural resources or deregulating forest sectors in order to increase international competitiveness. Although other studies have

[4q] For example, despite a peak in capital investment in 1986 and a dramatic decrease shortly thereafter, capital investment increased again in 1988, immediately after the removal of the log export ban.
[4r] Of course, the wood constraint has another reason for increasing the investments in current and new mills (Evison, 1990). In particular, Evison notes the increased use of improved inventory systems to reduce wood storage costs.
[4s] In addition, privatization of government forest gave mill owners an opportunity to secure a domestic source of wood fiber, and the new ownership structure required additional capital investment to develop the vertical integration of industrial-owned wood fiber resources with production facilities (Bilek and Horgan, 1992; Brown and Valentine, 1994).

focused on privatization or deregulation separately, the New Zealand case offers a chance to determine which reform has larger affects.

Deregulation reforms had the most significant impact on cost efficiency in the New Zealand wood processing industry. In 1984, the wood processing industry had numerous outdated mills (Tapsell, 1989). These industries, like other New Zealand manufacturing enterprises, were protected by numerous export subsidies, import licensing, price controls and export bans. Deregulation reforms lifted price controls, removed export bans and subsidies and eliminated import licensing. These reforms represented a negative shock to the already over-protected forest product processing sector. Production fell in the wood processing industry while costs increased because of higher raw material prices and capital investment. The removal of log export bans also created an opportunity for forest landowners to obtain greater returns by exporting logs rather than selling to domestic producers. This created a raw material input constraint that stimulated additional capital investment to make the domestic industry more efficient against international competitors. The increased capital investment coupled with lower production levels caused cost inefficiency in the production process. The decrease in cost efficiency further suggests that the industry's response is a short term event, and that cost efficiency gains may be detectable in the long run once industry capital adjustments equilibrate.

Surprisingly, privatization appears also to have decreased cost efficiency for the New Zealand wood processing industry in the short run. Although government timber suddenly became available, integrating this new forest land resource into corporate

structures resulted in decreased cost efficiency. A possible reason may be due to international investors who purchased government timber rights and then had to adjust to the New Zealand commercial environment, establish a forest management staff, modernize old mills and build new facilities. These results contradict a popular opinion that privatization always improves efficiency (Brown and Valentine, 1994; Trummel, 1994). For example, this paper shows that the effects of policy reforms on capital intensive wood industries can not be assessed without considering short run adjustments in capital flows within the industry.

The decrease in efficiency after privatization is smaller compared to the reduction in efficiency from deregulation of price controls and the removal of the log export ban. The primary reason for this is that deregulation of price controls and removal of the log ban encouraged expanded production from an outdated and inefficient industry, whereas privatization involved only an internal restructuring of resources and ownership of forest resources.

How far New Zealand is from attaining the efficient scale is too difficult to say at this point. Our results show that deregulation has been more of a detriment than privatization, due to the increased prices and resulting quick expansion that followed these rapidly implemented reforms. However, it has been deregulation and removal of log bans that created the most incentives for international investment in new mills and technologies (Tapsell, 1989). In the long run, LeChatelier's principle predicts this investment might improve cost efficiency once the optimal scale is reached. This is

because the long run response of the industry should be larger than the short run response given the scale adjustment.

The results here give insight into deregulation and privatization for other countries. Given similar starting conditions in New Zealand, what would happen in a nation that implements similar policy reform programs? The results suggest that countries which are debating privatizing forest resources should expect a short run efficiency loss in forest-based industries with comparative advantages, before adjustments to the newer efficient scales occur, and before the optimal capital-labor mix is determined for the new scale. Privatization and deregulation should not be viewed as a panacea for world competitiveness, at least not in the short run. With deregulation, short run efficiency decreases may occur as production first increases in existing mills, before the efficient scale is reached through an introduction of new technologies. With privatization of forest stocks, the short run decrease in cost efficiency will occur primarily through adjustment costs required to incorporate increased land resources into production infrastructures.

Future research on deregulation and privatization is needed, not only for New Zealand, but for other countries considering similar reforms. Future work should focus on firm-level panel data to examine the impacts of these policy events in more detail. Consideration should be given to distinguishing between the short run and long run. Another interesting future research topic would be to examine whether cost efficiency has short-run impacts on a nation's macroeconomic indicators. For example, inflows of capital investment coupled with production declines may decrease gross domestic

product. A change in national income may further complicate government tax revenues. Examining these possible negative impacts of cost inefficiency will ultimately determine the true costs of short and long-run responses to policy reforms.

Table 4A: Stochastic Frontier Parameter Estimates Before and After Deregulation of Price Controls for the New Zealand Wood Industry

Time Period	Cobb Douglas Model 1977-84	Cobb Douglas Model 1984-95
Constant	4.32*	2.80***
	(2.50)	(0.70)
Y (Export Output Volume)	0.77	0.71***
	(0.22)	(0.12)
Y^2	--	
W_1 (Price of Raw Materials)	0.46***	0.47***
	(0.08)	(0.04)
W_2 (Price of Capital)	0.34	0.59***
	(0.22)	(0.13)
W_3 (Price of Labor)	0.19	-0.14
	(0.27)	(0.15)
D_2 (Privatization)	--	-0.03
		(0.04)
D_3 (Removal of Log Export Ban)	--	0.10*
		(0.06)
T (Time Trend)	-0.3x10-2	0.01**
	(0.8x10-2)	(0.04)
$\sigma_v+\sigma_u$	0.09***	0.06*
	(0.02)	(0.04)
Log Likelihood Estimate	45.73	69.78

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level; -- variable not included in model.

Table 4B: Stochastic Frontier Parameter Estimates Before and After Deregulation of Price Controls for the New Zealand Wood Industry

Time Period	Translog Model 1977-84	Translog Model 1984-95
Constant	-3037.2***	-1881.5***
	(138.7)	(193.7)
Y (Export Output Volume)	656.79***	414.27***
	(28.39)	(37.08)
Y^2	-35.63***	-22.70***
	(1.59)	(1.58)
W_1 (Price of Raw Materials)	263.80***	199.38***
	(21.28)	(45.85)
W_2 (Price of Capital)	9.45	-87.55
	(43.21)	(195.6)
W_3 (Price of Labor)	-142.54**	-114.55
	(62.13)	(178.2)
W_{11}	-12.76***	-10.79**
	(2.01)	(3.34)
W_{22}	4.97	9.09
	(3.30)	(33.03)
W_{33}	7.03	2.05
	(9.65)	(27.63)
W_{12}	-0.03	1.51
	(1.79)	(10.01)
W_{13}	5.59*	9.43
	(3.37)	(8.91)
W_{23}	-6.32	-11.18
	(5.35)	(29.41)
YW_1	-27.72***	-21.67***
	(1.90)	(4.71)
YW_2	-1.14	10.46
	(4.79)	(19.52)
YW_3	15.41**	11.68
	(6.82)	(18.34)
D_2 (Privatization)	--	-0.98**
		(0.45)
D_3 (Removal of Log Export Ban)	--	-0.02
		(0.80)
T (Time Trend)	0.06***	0.001
	(0.02)	(0.13)
$\sigma_v+\sigma_u$	0.07	0.33***
	(0.14)	(0.06)
Log Likelihood Estimate	40.56	18.13

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level; -- variable not included in model.

Table 4C: Stochastic Frontier Parameter Estimates Before and After Privatization for the New Zealand Wood Industry

Time Period	Cobb Douglas Model 1977-90	Cobb Douglas Model 1990-95
Constant	5.95***	-2.02
	(1.49)	(2.92)
W_1(Price of Raw Materials)	0.30***	1.03***
	(0.08)	(0.39)
W_2 (Price of Capital)	0.31***	0.52
	(0.08)	(0.42)
W_3 (Price of Labor)	0.25*	-0.43
	(0.15)	(0.27)
Y (Export Output Volume)	0.59***	1.56***
	(0.16)	(0.45)
D_1 (Deregulation of Price Controls)	0.13***	--
	(0.05)	
D_3 (Removal of Log Export Ban)	0.14**	--
	(0.07)	
T (Time Trend)	-0.4x10-2	-0.02
	(0.3x10-2)	(0.01)
$\sigma_v+\sigma_u$	0.07	0.06***
	(0.05)	(0.02)
Log Likelihood Estimate	76.84	40.62

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level; -- variable not included in model.

Table 4D: Percentage Change in Mean Cost Inefficiency of the New Zealand Wood Processing Industry Using the Cost Function Approach

Time Period	σ_u	Mean Cost Inefficiency	% Change in Mean Cost Inefficiency	Policy Event	Functional Form
1877-84	0.00193	0.0015		Pre-Deregulation	Translog
1984-95	0.11155	0.0890	58.33%	Post-Deregulation	Translog
1977-87	0.01547	0.0123		Pre-Removal of the log export ban	Translog
1987-95	0.07277	0.0581	372.36%	Post-Removal of the log export ban	Translog
1977-90	0.00178	0.0014		Pre-Privatization	Cobb Douglas
1990-95	0.00395	0.0032	128.57%	Post-Privatization	Cobb Douglas

Table 4E: Percentage Change in Wood Industry Inputs (Mean Values) Before and After Reform Policy Implementation

Inputs	Percent Change After Removal of Price Controls	Percent Change After Removal of the Log Export Ban	Percent Change After Privatization
Raw Material	55.34%	44.13%	56.13%
Capital	372.41%	134.69%	103.32%
Labor	-10%	-10.7%	-3.5%

Appendix 4: Estimation of Mean Cost Efficiency from a Stochastic Cost Function

Specification

An estimable expression for MTI can be obtained from the density function of ε_i, (Jondrow et al. 1982)

$$f_i(\varepsilon_i) = \frac{2}{\sigma} f_i^*\left(\frac{\varepsilon_i}{\sigma}\right)\left[1 - F_i^*(\varepsilon_i \lambda \sigma^{-1})\right]; \qquad -\infty \leqq \varepsilon_i \leqq +\infty, \tag{1}$$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \sigma_u/\sigma_v$, and $f_i^*(.)$ and $F_i^*(.)$ are the density and distribution functions, respectively. The density is asymmetric around zero, with its mean and variance given by (Jondrow et al. 1982),

$$E(\varepsilon_i) = E(u_i) = -\frac{\sqrt{2}}{\sqrt{\pi}}\sigma_u, \text{ and} \tag{2}$$

$$V(\varepsilon_i) = V(u_i) + V(v_i) = \left(\frac{\pi - 2}{\pi}\right)\sigma_u^2 + \sigma_v^2. \tag{3}$$

Using these definitions, the log likelihood function is given by,

$$\ln L\left(C_i \middle| \beta_j, \lambda, \sigma^2\right) = N \ln \frac{\sqrt{2}}{\sqrt{\pi}} + N \ln \sigma^{-1} + \sum_{i=1}^{N} \ln\left[1 - F^*(\varepsilon_i \lambda \sigma^{-1})\right] - \frac{1}{2\sigma^2}\sum_{i=1}^{N} \varepsilon_i^2, \tag{4}$$

where N is the total number of observations.

The maximum likelihood estimates of σ^2, l, and b_j are estimated by solving the following equations,

$$\frac{\partial \ln L}{\partial \sigma^2} = -\frac{N}{2\sigma^2} + \frac{1}{2\sigma^4}\sum_{i=1}^{N}\left(C_i - \beta_j' w_{ij}\right)^2 + \frac{\lambda}{2\sigma^3}\sum_{i=1}^{N}\frac{f_i^*}{(1 - F_i^*)}\left(C_i - \beta_j' w_{ij}\right), \tag{5}$$

$$\frac{\partial \ln L}{\partial \lambda} = -\frac{1}{\sigma}\sum_{i=1}^{N}\frac{f_i^*}{(1 - F_i^*)}\left(C_i - \beta_j' w_{ij}\right), \tag{6}$$

$$\frac{\partial \ln L}{\partial \beta} = \frac{1}{\sigma^2}\sum_{i=1}^{N}\left(C_i - \beta_j' w_{ij}\right)w_{ij} + \frac{\lambda}{\sigma}\sum_{i=1}^{N}\frac{f_i^*}{(1 - F_i^*)}w_{ij}. \tag{7}$$

Chapter 5

Concluding Remarks

In the late 1970's and early 1980's, New Zealand's economy was experiencing poor macroeconomic conditions. In addition, highly restrictive domestic policies prevented forest product manufacturing industries from competing effectively in the international wood market. Efforts to remedy this situation occurred after the election of the Labour party in 1984. In the same year, price controls on input and output commodities were lifted. In 1987, the New Zealand Forest Service was dismantled, and its public forest assets were corporatized into the New Zealand Forestry Corporation. At the advent of the New Zealand Forestry Corp., the log export ban was removed. In 1990, privatization of the Forestry Corporation's capital and land holding started. The essence of this dissertation was to study the impacts of these three reforms on the production, total cost, and efficiency in the New Zealand forest products manufacturing sector.

The purpose of this final chapter is to revisit the results established in Chapter 2-4. In doing so, my focus will be on summarizing and comparing the findings for each chapter. In addition, the study's contributions, policy implications, and future research opportunities will be elaborated upon.

In Chapter 2, the purpose was to analyze the impacts of deregulation and privatization on supply in the wood and paper industries. This was done by specifying

and estimating production functions for both industries. These policy reforms were estimated using a time series production function that incorporated variables depicting each event. The advantage of specifying this function directly as opposed to relying on duality theory is the benefit gained by estimating the error term. This methodology is a two stage process, where factor demands are estimated prior to final estimation avoided endogeneity problems. Results show that deregulation of price controls decreased production for the wood industry while it increased production for the paper industry. The increased cost of raw material reduced wood industry production. The paper industry was able to purchase unused fiber and increased paper production. After the removal of the log export ban, production decreased for both industries. Forest landowners exported large quantities of wood, because foreign buyers could offer higher prices than domestic producers. This created a raw material input constraint for domestic wood and paper industries that resulted in short run reduced production. In addition, the overall economy was in a policy induced recession which may have resulted in depressed domestic demand for forest products. Privatization had little impact on production in either industry, although some evidence suggests that the paper sector was able to secure new fiber sources, while the wood industries lost fiber sources. Of the deregulation and privatization reforms, deregulation had the greater impact on cost efficiency.

In Chapter 3, the purpose was to analyze the impacts of deregulation and privatization on total cost in the wood and paper industries. The hope here was to obtain additional evidence on how reform policies impacted the forest manufacturing sector.

These policy reforms were investigated using a time series total cost function that incorporated variables depicting each event. The advantage of the cost approach is that it avoids potential problems with endogeneity. Results show that deregulation of price controls decreased total cost for the wood industry, but increased total cost for the paper industry. The lower total cost in the wood industry is a result of the lower production established in Chapter 2. The higher total cost for the paper industry is a due to greater production levels for the paper industry. After the removal of the log export ban, total cost decreased for both industries. The input constraint previously noted decreased production for both industries, and this led to lower total cost levels. However, privatization had little impact on production in either industry, although some evidence suggests that the paper industry experienced lower total costs, while the wood industry had higher total costs. Of the deregulation and privatization reforms, deregulation had the greater impact on cost efficiency.

In Chapter 4, the purpose was to analyze the impacts of deregulation and privatization on cost efficiency in the wood processing industry. These policy reforms were estimated using a stochastic total cost frontier model that incorporated variables depicting each event. This model is estimated for pre- and post-reform policies. In all cases, cost efficiency decreased after reform policy implementation. This response suggests that short-term adjustments occurred, because of higher levels of capital investment. Of the deregulation and privatization reforms, deregulation again had the greater impact on cost efficiency.

The contribution this study offers is its analysis of how deregulation and privatization affected the New Zealand forest manufacturing sector. The study specifically focuses on the impacts of these policy events on production, total cost, and cost efficiency. To the best of my knowledge, no econometric study exists that compares these policy reforms for the forest manufacturing sector in New Zealand or elsewhere.

There are several general policy implications that can be drawn out of this dissertation. The first concerns the impacts of deregulation. Deregulation leads to short-run fluctuations in production, total cost, and cost efficiency for the wood and paper processing industries. These fluctuations may result whenever these industries try to adapt to new operating environments. Inflows of capital investment are made to make existing production systems more productive and efficient. The time required to install new equipment and build new facilities may create disruptions in production processes that reduce output manufacture and affect aggregate supply.

The second policy implication is that trade reforms (or reforms designed to open the economy) may lead to greater production and cost fluctuations than other restructuring policies. Trade reforms expose domestic industries to increased competition from international competitors. This increased competition will force domestic manufacturers to increase capital investment in order to become more productive and efficient. If these manufacturers cannot compete in this new environment, capital will shift to other sectors.

The third policy implication is that forest sectors that are highly capital intensive and have a comparative advantage may become more inefficient as inputs become more

expensive when the economy opens. As the New Zealand economy opened, capital investment increased in the forest manufacturing sector, despite a decrease in wood industry production. This suggested that investors viewed the New Zealand forest products industrial base as having a comparative advantage over other sectors of the economy. Moreover, high rates of return facilitated an inflow of capital. At some point when enough capital has entered the economy, the rates of return for capital will decrease. In New Zealand, the evidence of this is the decline in long-term interest rates in the 1990s from highs during the 1980s.

The fourth policy implication is that deregulation may have a more substantial impact on production and cost in forest manufacturing sector than privatization. In the New Zealand case, after the removal of price controls, both the wood and paper industries responded to the adjustment of rising raw material prices. After the removal of the log export ban, both industries responded to the higher export prices for logs. In essence, deregulation reforms resulted in substantial shock because price adjustments affected production processes in both the wood and paper industries, privatization was mainly a reallocation of inputs to old and new producers.

The fifth policy implication is that the New Zealand experience may be used as a guide for countries with large public forest owner-ships. Currently, Australia, Canada, several Latin American countries, and the United States are considering deregulation and privatization reforms. Australia is probably further along than the other countries. Hall's (1997) study suggests keeping in mind the special conditions in New Zealand such as an extensive exotic plantations and history of government production enterprises

before implementing privatization reform. Hall concludes that, for the United States, privatization programs should be limited to some National forest lands where wood production is the emphasis. In addition, Hall suggests that reform proceed slowly and cautiously incorporating a trial and error period to develop appropriate procedures before mass implementation. Hall's conclusion, and the results of my study, suggest the possibility of implementing privatization in a limited sense to forest sectors outside New Zealand.

Future research in studying the impacts of deregulation and privatization is needed to broaden the understanding of their impacts. A broader understanding will enable policy makers to design policies that are more efficient. Four major themes warrant further study. They are firm level analysis using panel data, cross country comparisons, evaluation of macroeconomic indicators, and landowner behavior.

Firm level analysis is necessary to provide a greater understanding of how specific firms responded to deregulation and privatization. This approach could be enhanced by using panel data to observe location and infrastructure impacts. The potential information from exploring this theme may allow investors to gain greater returns by channeling their capital to firms with greater long-run prospects. In addition, it may allow greater accuracy in targeting industries with comparative advantages over others.

The second theme should focus on the short-run impacts of deregulation and privatization on macroeconomic indicators. For example, inflows of capital investment, coupled with production declines may decrease gross domestic product. A change in

national income may further compromise government tax revenues. These reforms may affect another macroeconomic indicator, such as interest rates. Impacts on interest rates may affect both the influx of capital and domestic housing starts. High interest rates may induce greater capital investment and reduce housing starts. Low interest rates may curtail new capital investment, but stimulate new housing construction. Exploring this potential link between reform policies and interest rates may stimulate policy designs that soften fluctuations in seasonal unemployment.

The third potential research direction would be to analyze the impacts of deregulation and privatization on landowner behavior. Efforts to model changes in harvesting decisions and forest establishment may provide important information of the sectors long-run timber supply. In addition, modeling cost efficiency changes may facilitate policy design that more effectively increases landowner production while lowering their costs. Another research extension may focus on how privatization of public forests affects landowner decisions regarding non-timber uses.

Finally, future work should focus on comparing results among countries implementing similar policy reforms. Not all countries experiencing deregulation and privatization initiate reforms under the same initial conditions. In New Zealand's case, the forest sector possessed large acreages of plantation forests. In Russia, the forest estate consists primarily of natural forests. The initial conditions before reforms may determine the more efficient adjustment path for each sector or economy. In addition, this information may allow policy makers to design instruments that consider specific starting conditions for each country.

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Appendix A: Results and Description of Misspecification Tests

This appendix outlines the results and methods used to test the model assumptions of normality, linearity, homoskedasticity, parameter stability, and independence (autocorrelation). The methods used are identical for all functional forms and models estimated in this dissertation. For testing the normality assumption, I used a D'Agostino-Pearson procedure in a Gauss subroutine developed by Spanos et al. (1992). When testing the other four assumptions, I use a joint conditional mean and variance procedure. Joint tests are used in this study because they provide a more comprehensive tool for determining misspecification error than separate individual tests (McGuirk et al., 1993). Spanos (1986) claims that the key advantage in such test is that fewer hypotheses are maintained.

D'Agostino-Pearson Normality Tests

Joint Hypothesis

$H_0^{(1)}$: $\alpha_3=0$, $H_0^{(2)}$: $\alpha_4=0$
$H_1^{(1)}$: $\alpha_3\neq0$, $H_1^{(21)}$: $\alpha_4\neq0$

Separate Skewness test

H_0: $\alpha_3=0$
H_1: $\alpha_3\neq0$

Separate Kurtosis test

H_0: $\alpha_4=3$
H_1: $\alpha_4\neq3$

Joint Misspecification Testing on Conditional Mean

This section conduct a joint conditional mean procedure and separately tests each assumption.

Restricted Model

$$Y_{jk} = f\left(X_{ijk}, d_g, t; \alpha\right) + \varepsilon_{jk}$$

Unrestricted Model

$$Y_{jk} = f\left(X_{ijk}, \hat{Y}^2_{jk}, \hat{Y}^3_{jk}, \hat{u}_{jk-1}, \hat{u}_{jk-2}\ \hat{D}; \beta \right) + \varepsilon_{jk}$$

H_0: Assumptions of parameter stability, linearity, and independence hold
H_1: At least one assumption does not

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u)

where:

j	Industry
i	Independent type
Y_i	Dependent variable
X_{ij}	Independent variable
$\hat{Y}_{ij}$	Predicted values for dependent variable
$\hat{u}_{t-1}$	Residuals lagged
D	Policy reform variable
ε_{jk}	Error term
RRSS	Restricted residual sums of square
URSS	Unrestricted residual sums of square
K	Number of observations
M_u	Number of parameters in unrestricted model
M_r	Number of parameters in restricted model

Separate Test of Parameter Stability Assumption

Restricted Model

$$Y_{jk} = f\left(X_{ijk}, \hat{Y}^2_{jk}, \hat{Y}^3_{jk}, \hat{u}_{jk-1}, \hat{u}_{jk-2}; \beta \right) + \varepsilon_{jk}$$

Unrestricted Model

Is the Unrestricted model in the joint test above.

H_0: Parameter stability
H_1: No parameter stability

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u)

where:

all variables are previously defined.

Separate Test of Linearity Assumption

Restricted Model

$$Y_{jk} = f\left(X_{ijk}, \hat{u}_{jk-1}, \hat{u}_{jk-2}, D; \beta \right) + \varepsilon_{jk}$$

Unrestricted Model

Is the Unrestricted model in the joint test above.

H_0: Linear
H_1: Not linear

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u)

where:

all variables are as previously defined.

Separate Test of True Autocorrelation Assumption

Restricted Model

$$Y_{jk} = f\left(X_{ijk}, \hat{Y}_{jk}^{2}, \hat{Y}_{jk}^{3}, D; \beta \right) + \varepsilon_{jk}$$

Unrestricted Model

Is the Unrestricted model in the joint test above.

H_0: No true autocorrelation
H_1: True autocorrelation

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u)

where:

All variables are as previously defined.

Joint Misspecification Testing of the Conditional Variance

This misspecification regime tests the joint conditional variance test and separately examines the relevance of each assumption in the joint test.

Restricted Model

$$\hat{u}_t^2 = \alpha_0 + \nu_t$$

$\hat{u}_t$ used in this model was estimated from the original OLS regression in Question #1.

Unrestricted Model

$$\hat{u}_{jk}^2 = f\left(X_{ijk}, \hat{Y}_{jk}^2, \hat{Y}_{jk}^3, \hat{u}_{jk-1}, \hat{u}_{jk-2}\ D; \hat{\beta} \right) + \varepsilon_{jk}$$

H_0: Assumptions of parameter stability, static heterogeneity, and dynamic heterogeneity hold
H_1: At least one does not hold

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(n-M_u-M_0)

where:

All variables are as previously defined.

Separate Test of Parameter Stability Assumption

Restricted Model

$$\hat{u}_{jk}^{2} = f\left(X_{ijk}, \hat{Y}_{jk}^{2}, \hat{Y}_{jk}^{3}, \hat{u}_{jk-1}, \hat{u}_{jk-2}, D; \beta \right) + \varepsilon_{jk}$$

Unrestricted Model

Is the Unrestricted model in the joint test above.

H_0: Parameter stability
H_1: No parameter stability

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u-M_0)

where:

All variables are as previously defined.

Separate Test of Static Heterogeneity Assumption

Restricted Model

$$\hat{u}_{jk}^{2} = f\left(X_{ijk}, \hat{u}_{jk-1}, \hat{u}_{jk-2}, D; \beta \right) + \varepsilon_{jk}$$

Unrestricted Model

Is the Unrestricted model in the joint test above.

H_0: Static heterogeneity
H_1: No static heterogeneity

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u-M_0)

where:

All variables are as previously defined.

Separate Test of Dynamic Heterogeneity Assumption

Restricted Model

$$\hat{u}_{jk}^{2} = f\left(X_{ijk}, \hat{Y}_{jk}^{2}, \hat{Y}_{jk}^{3}, D; \beta \right) + \varepsilon_{jk}$$

Unrestricted Model

Is the Unrestricted model in the joint test above.

H_0: Dynamic heterogeneity
H_1: No dynamic heterogeneity

F-Statistic =(RRSS-URSS)/(M_u-M_r)/(URSS)/(K-M_u-M_0)

where:

All variables are as previously defined.

Results

Appendix Tables A1 & A2 present the misspecification test results for the Cobb Douglas and Generalized Leontief production and cost models used in Chapter's 2 and 3. The high P-values indicate that all production and cost models fail to reject the null hypothesis that normality, linearity, homoskedasticity, parameter stability, and independence hold.

Appendix Table A1: Misspecification Tests for the New Zealand's Wood Industry's Production and Cost Models for 1977-95 Time Period

Test	**Cobb Douglas** Production (P-Values)	**Generalized Leontief** Production (P-Values)	**Cobb Douglas** Cost (P-Values)	**Generalized Leontief** Cost (P-Values)
Individual Test				
Normality				
D'Agostino-Pearson	0.015348	0.303831	0.735115	0.017318
Joint Tests				
Overall Mean Test	0.999907	0.999964	0.999992	0.999820
Parameter Stability	0.999974	0.999299	0.999990	0.999447
Functional Form				
RESET (3)	0.999120	0.997970	0.999236	0.997210
True Autocorrelation	0.988122	0.994518	0.997288	0.996106
Overall Variance Test	1.000000	1.000000	1.000000	1.000000
Parameter Stability	0.999991	0.999994	1.000000	0.999986
Static Heteroskedasticity	0.999832	0.999859	0.999982	0.998409
Dynamic Heteroskedasticity	0.996542	0.998908	0.999546	0.998923

Appendix Table A2: Misspecification Tests for the New Zealand's Paper Industry's Production and Cost Models for 1977-95 Time Period

Test	**Cobb Douglas** Production (P-Values)	**Generalized Leontief** Production (P-Values)	**Cobb Douglas** Cost (P-Values)	**Generalized Leontief** Cost (P-Values)
Individual Test				
Normality				
D'Agostino-Pearson	0.007332	0.00004	0.872360	0.000738
Joint Tests				
Overall Mean Test	0.999977	0.999858	0.999977	0.999985
Parameter Stability	0.999993	0.997520	0.999992	0.998759
Functional Form				
RESET (3)	0.999563	0.995503	0.999890	0.997209
True Autocorrelation	0.994722	0.994092	0.999890	0.999651
Overall Variance Test	1.000000	1.000000	1.000000	1.000000
Parameter Stability	0.999963	0.999971	0.999989	0.999999
Static Heteroskedasticity	0.999966	0.999664	0.999566	0.999831
Dynamic Heteroskedasticity	0.999866	0.999731	0.999396	0.999928

Appendix B

This appendix presents the parameter estimates for the Cobb Douglas and Translog functional forms. The purpose is to show that the policy reforms such as deregulation of price controls, removal of the log export ban and corporatization, and privatization were a surprise, resulting in a shift of the wood and paper industry's aggregate production and total cost functions.

Appendix Table B1 shows that the lagged dependent parameter estimates are mainly insignificant for the wood industry. For the Translog specification, none of the lagged dependent coefficients are significant, suggesting that production was independent across time. This is also verified by autocorrelation tests for independence outlined in Appendix A. In addition, parameter stability held before and after each reform policy implementation. Although two lags are significant for the Cobb Douglas model, removal of the log export ban and privatization were know for about a year prior to implementation. The fifth and sixth quarter lags are not significant in either model, suggesting that a shift occurred. In addition, autocorrelation was not found in either specification (Appendix A) while parameter stability held after implementation of reform policies.

Appendix Table B2 suggests that the paper industry was not surprised by the implementation of policy reforms. The literature suggests that the events were a surprise while misspecification testing indicate that production was independent across time and that parameter stability held for the paper industry across time. Although most lagged parameter estimates are significant for the Cobb Douglas model, most of the non-lagged

coefficients are not significant, making the specification not useful. The Translog specification shows two significant lagged parameter estimates, but most non-lagged coefficients are not significant, leading to the same interpretation as for the Cobb Douglas model. Therefore it is fair to conclude that the implementation of the policy reforms came as a surprise to the paper processing industry.

Appendix Table B3 and B4 present coefficients for lagged dependent variables that are not significant for either the wood or paper industries. In addition, these same coefficients are not significant across functional forms for either industry. These results suggests that the total cost functions responded as a shift to the implementation of policy reforms for both the wood and paper processing industries. Misspecification tests in Appendix A confirm this result by showing that the total cost function for each industry to have independence and parameter stability across time.

Appendix Table B1: Parameter Estimates for Lagged Production Functions in the New Zealand Wood Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	1.35*		36.40
	(0.80)		(1787)
Y_{n-1}	1.22***		0.82
	(0.14)		(0.70)
Y_{n-2}	-0.43		-0.31
	(0.22)*		(0.92)
Y_{n-3}	$-0.48x10^{-2}$		$-0.8x10^{-1}$
	(0.22)		(0.98)
Y_{n-4}	-0.17		-0.15
	(0.23)		(0.96)
Y_{n-5}	0.12		-0.07
	(0.22)		(0.95)
Y_{n-6}	$0.24x10^{-1}$		0.21
	(0.12)		(0.60)
X_1 (Raw Material)	0.11***		5.45
	(0.03)		(10.54)
X_2 (Capital)	-0.02		-0.05
	(0.03)		(13.20)
X_3 (Labor)	-0.04		-8.67
	(0.05)		(222.5)
X_4 (Energy Use)	$0.45x10^{-2}$		-2.78
	(0.06)		(140.4)
X_{11}	--		0.17
			(0.18)
X_{22}	--		-0.04
			(0.08)
X_{33}	--		-0.54
			(12.48)
X_{44}	--		-0.30
			(6.27)
X_{12}	--		0.02
			(0.07)
X_{13}	--		-0.21
			(0.57)
X_{14}	--		-0.36
			(0.64)
X_{23}	--		0.10
			(0.81)
X_{24}	--		-0.06
			(0.69)
X_{34}	--		1.13
			(9.62)

Appendix Table B1 (continued): Parameter Estimates for Lagged Production Functions in the New Zealand Wood Industry

D_1 (Deregulation of price controls)	-0.01	$0.63x10^{-3}$
	(0.02)	(0.09)
D_2 (Removal of log export ban)	$0.77x10^{-3}$	-0.07
	(0.02)	(0.12)
D_3 (Privatization)	-0.02	0.10
	(0.02)	(0.17)
T (Rate of technical change)	$0.27x10^{-2}$**	$-0.38x10^{-2}$
	$(0.11x10^{-2})$	$(0.7x10^{-2})$

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels.
Parenthesis is standard error.

Appendix Table B2: Parameter Estimates for Lagged Production Functions in the New Zealand Paper Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	4.53***		-28.99
	(1.50)		(121.8)
Y_{n-1}	1.55***		1.33***
	(0.14)		(0.24)
Y_{n-2}	-0.67***		-0.49
	(0.22)		(0.30)
Y_{n-3}	0.04		0.17
	(0.22)		(0.22)
Y_{n-4}	-0.53**		-0.57**
	(0.21)		(0.22)
Y_{n-5}	0.79***		0.65**
	(0.21)		(0.25)
Y_{n-6}	-0.34***		-0.21
	(0.12)		(0.17)
X_1 (Raw Material)	$0.74x10^{-3}$		3.71
	$(0.30x10^{-1})$		(5.68)
X_2 (Capital)	$-0.79x10^{-2}$		1.17
	$(0.99x10^{-2})$		(2.07)
X_3 (Labor)	-0.32***		$0.38x10^{-3}$
	(0.11)		$(0.14x10^{-2})$
X_4 (Energy Use)	$-0.37x10^{-1}$		1.56
	$(0.48x10^{-1})$		(17.53)
X_{11}	--		0.61
			(0.72)
X_{22}	--		$0.76x10^{-3}$
			$(0.36x10^{-1})$
X_{33}	--		$0.38x10^{-8}$
			$(0.15x10^{-7})$
X_{44}	--		$0.84x10^{-1}$
			(1.22)
X_{12}	--		$0.41x10^{-1}$
			$(0.93x10^{-1})$
X_{13}	--		$-0.12x10^{-3}$*
			$(0.75x10^{-4})$
X_{14}	--		-0.40
			(0.46)
X_{23}	--		$-0.75x10^{-5}$
			$(0.21x10^{-4})$
X_{24}	--		$-0.89x10^{-1}$
			(0.16)
X_{34}	--		$0.22x10^{-4}$
			$(0.11x10^{-3})$

Appendix Table B2 (continued): Parameter Estimates for Lagged Production Functions in the New Zealand Paper Industry

D_1 (Deregulation of price controls)	$0.71x10^{-2}$	$0.76x10^{-1}$
	$(0.23x10^{-1})$	$(0.51x10^{-1})$
D_2 (Removal of log export ban)	$-0.16x10^{-1}$	$0.18x10^{-3}$
	$(0.21x10^{-1})$	$(0.25x10^{-1})$
D_3 (Privatization)	$-0.32x10^{-2}$*	$0.56x10^{-2}$
	$(0.18x10^{-1})$	$(0.25x10^{-1})$
T (Rate of technical change)	$0.14x10^{-2}$*	$-0.13x10^{-2}$
	$(0.82x10^{-3})$	$(0.16x10^{-2})$

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels.
Parenthesis is standard error.

Appendix Table B3: Parameter Estimates for Lagged Total Cost Functions in the New Zealand Wood Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	2.34***		-1880.1***
	(0.88)		(72.20)
TC_{n-1}	0.06		$-0.42x10^{-3}$
	(0.74)		$(0.38x10^{-3})$
TC_{n-2}	0.46		$-0.27x10^{-3}$
	(0.78)		$(0.36x10^{-3})$
TC_{n-3}	-0.22		$-0.22x10^{-4}$
	(0.77)		$(0.37x10^{-3})$
TC_{n-4}	0.27		$-0.49x10^{-3}$
	(0.76)		$(0.39x10^{-3})$
TC_{n-5}	-0.22		$-0.57x10^{-4}$
	(0.75)		$(0.35x10^{-3})$
TC_{n-6}	0.25		$-0.26x10^{-3}$
	(0.42)		$(0.25x10^{-3})$
Y (Output)	0.39		400.72***
	(0.42)		(11.40)
Y^2	--		-21.32***
			(0.49)
W_1 (Price of raw material)	0.41***		203.49***
	(0.07)		(12.22)
W_2 (Price of capital)	0.48***		36.79
	(0.09)		(44.45)
W_3 (Price of labor)	0.06		-217.91***
	(0.12)		(40.42)
W_{11}	--		-11.08***
			(0.97)
W_{22}	--		2.57
			(3.26)
W_{33}	--		-16.59***
			(4.50)
W_{12}	--		-5.19**
			(2.640)
W_{13}	--		14.91***
			(2.34)
W_{23}	--		3.03
			(3.48)
YW_1	--		-21.41***
			(1.11)
YW_2	--		-2.92
			(4.68)
YW_3	--		21.92***
			(4.24)

Appendix Table B3 (continued): Parameter Estimates for Lagged Total Cost Functions in the New Zealand Wood Industry

D_1 (Deregulation of price controls)	0.17***	-0.18
	(0.06)	(0.24)
D_2 (Removal of log export ban)	-0.13**	-0.81**
	(0.05)	(0.34)
D_3 (Privatization)	0.19***	$0.64x10^{-1}$
	(0.05)	(0.30)
T (Rate of technical change)	$-0.34x10^{-2}$	$0.51x10^{-1}$***
	$(0.28x10^{-2})$	$(0.18x10^{-1})$

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels. Parenthesis is standard error.

Appendix Table B4: Parameter Estimates for Lagged Total Cost Functions in the New Zealand Paper Industry

Variables	Cobb Douglas	Generalized Leontief	Translog
Constant	10.36***		-12.58
	(0.59)		(37.82)
TC_{n-1}	-0.61		$0.11x10^{-1}$
	(0.54)		(0.13)
TC_{n-2}	0.77		$0.84x10^{-1}$
	(0.51)		(0.12)
TC_{n-3}	$0.96x10^{-1}$		$0.35x10^{-1}$
	(0.48)		(0.12)
TC_{n-4}	-0.18		$0.75x10^{-1}$
	(0.50)		(0.12)
TC_{n-5}	-0.56		-0.12
	(0.51)		(0.13)
TC_{n-6}	0.63**		-0.16
	(0.27)		(0.12)
Y (Output)	-0.32		4.07
	(0.28)		(7.89)
Y^2	--		$0.42x10^{-1}$
			(0.45)
W_1 (Price of raw material)	0.43***		5.57
	$(0.65x10^{-1})$		(8.20)
W_2 (Price of capital)	0.12*		-5.63
	$(0.66x10^{-1})$		(4.74)
W_3 (Price of labor)	0.35***		2.27
	$(0.86x10^{-1})$		(5.31)
W_{11}	--		0.45
			(1.02)
W_{22}	--		-0.26
			(1.02)
W_{33}	--		0.94
			(0.84)
W_{12}	--		0.30
			(0.83)
W_{13}	--		-0.92*
			(0.51)
W_{23}	--		$0.73x10^{-1}$
			(0.61)
YW_1	--		-1.16
			(0.84)
YW_2	--		0.72
			(0.64)
YW_3	--		0.32
			(0.69)

Appendix Table B4 (continued): Parameter Estimates for Lagged Total Cost Functions in the New Zealand Paper Industry

D_1 (Deregulation of price controls)	0.19***	$0.99x10^{-1}$**
	$(0.37x10^{-1})$	$(0.46x10^{-1})$
D_2 (Removal of log export ban)	$-0.47x10^{-1}$	$-0.62x10^{-2}$
	$(0.33x10^{-1})$	$(0.44x10^{-1})$
D_3 (Privatization)	$0.27x10^{-1}$	-0.12**
	$(0.44x10^{-1})$	$(0.49x10^{-1})$
T (Rate of technical change)	$0.19x10^{-2}$	$0.89x10^{-2}$**
	$(0.18x10^{-2})$	$(0.34x10^{-2})$

Note: * means significant at the 10% level; ** means significant at the 10% and 5% levels; *** means significant at the 10%, 5% and 1% levels. Parenthesis is standard error.

Appendix C: Tests for Appropriate Functional Forms

The purpose for this Appendix is to present the F-statistics that were computed to determine the best functional forms for the production and cost models in Chapters 1 and 2. Appendix Table C1 indicates that both the Translog and Cobb Douglas specifications are appropriate for the wood industry's production models. For the paper industry's production models, the Translog, Generalized Leontief, and Cobb Douglas forms are appropriate specifications. For the paper industry's cost models, only the Translog and Cobb Douglas specifications are appropriate.

Appendix Table C1: F-Statistics Functional Forms Specified

Wood Industry	**Production**	**Generalized Leontief**	**Cobb Douglas**
	Translog	4.878	0.0036
		(0.0019)	(1.0000)
	Cost		
	Translog	6.3149	*
		(0.0003)	
Paper Industry	**Production**		
	Translog	0.3426	0.0004
		(0.8480)	(1.0000)
	Cost		
	Translog	4,860	0.0016
		($1.9x10^{-7}$)	(1.0000)

Note: - The * indicates that an F-Statistic could not be computed. Parenthesis is P-value.

Vita

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EDUCATION

Doctor of Philosophy in Forestry, expected Summer 1998, Virginia Polytechnic Institute and State University, Department of Forestry, Blacksburg, Virginia USA
Concentration: Forest Resource Economics and Management

Master of Arts in Economics, 1996, Virginia Polytechnic Institute and State University, Department of Economics, Blacksburg, Virginia USA

Fulbright Scholar, 1995, Lincoln University, Department of Economics and Marketing, Canterbury New Zealand
Research Focus: Forest resource accounting in the forest sector of small open economies

Master of Forestry, 1992, Yale University, School of Forestry and Environmental Studies, New Haven, Connecticut USA
Concentration: Forest Management
Masters Project: Evaluation of Growth & Yield Models for Tropical Rain Forests

Bachelors of Science in Forestry, 1987, University of Maine, College of Forest Resources, Orono, Maine USA
Concentration: Forest Management

Doctoral Fields of Specialization: Natural resource and forest economics, policy analysis and applied econometrics

Dissertation: "Analysis of Policy Reforms in the New Zealand Forest Products Manufacturing Sector"

Essay 1: "Policy impacts on New Zealand's forest industrial production structures"

Essay 2: "Policy impacts on New Zealand's forest industrial cost structures"

Essay 3: "Policy impacts on cost efficiency in the New Zealand wood industry"

The purpose of this dissertation is to analyze the impacts of deregulation and privatization on the New Zealand forest sector. In the first two essays, pre- and post-policy reform models are developed and estimated to evaluate structural changes in the wood and paper processing industry's cost and production. The policies analyzed are deregulation of price controls, removal of the log export ban, and privatization. The results suggest that costs increased and production decreased after implementation of policy reforms. The implications are that reform policy design should consider the short term impacts which may adversely affect the entire economy. These short term impacts should be evaluated along with expected positive long run changes. Moreover, deregulation is found to be a more significant impact than privatization on the forest sector. In the third essay, changes in cost efficiency are analyzed using

stochastic frontier models estimated for each policy event. These results show that cost efficiency decreases after policy implementation, suggesting that adjustment costs are present which adversely affect the production process in the short run. These short run costs are a result of capital investment necessary to obtain long run cost efficiency goals.

SPECIAL EDUCATION

Agroforestry course, United Nations University for Peace, San José, Costa Rica 1988
Language and cross cultural training school, U.S. Peace Corps, Santa Ana, Costa Rica 1988
Leadership training school for noncommissioned officers, US Army, Fort Indiantown Gap, Pennsylvania 1985
Helicopter maintenance school, US Army, Fort Rucker, Alabama 1983
Basic training, US Army, Fort Leonard Wood, Missouri 1982

PROFESSIONAL EXPERIENCE

1994-Present Research Assistant, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA

Worked on a team project that involved conducting an economic analysis of the benefits and costs of reforestation in the lower Mississippi Delta. The work included designing an economic model to represent landowner behavior and evaluate alternative reforestation strategies for marginal farmland.

1995-1997 Teaching Assistant, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA

Forest Management (Undergraduate)
Forest Policy (Undergraduate)
Senior Capstone Class in Forest Management (Undergraduate)

1992-1994 Forestry Research Analyst, Winrock International Institute of Agricultural Development, Morrilton, Arkansas USA

Developed and adapted econometric models to study real price increases for timber and logs in Alaska and the Pacific Rim. Assisted in a team effort to develop a Farm Forestry and Agroforestry Evaluation model for use in Arkansas and southeastern United States. Conducted evaluation of 8-year farm forestry project in Pakistan and program development in New Zealand. Co-lectured graduate level course in *Economics of Forest Management and Policy Decisions* at Yale University, School of Forestry and Environmental Studies. Coordinated workshops on problem solving and logging safety; conducted field trips on Central New England forestry. Provided cost support to development projects in India and Dominican Republic and assisted with book editing activities. Managed and maintained forestry program's computer systems.

1991 Research Consultant, Harvard Institute of International Development, Cambridge, Massachusetts USA

Conducted an evaluation of growth and yield models for potential use in the tropical rain forests of Malaysia. Compared models on the basis of inputs, growth functions, subroutines and outputs.

1991 Forest Management Intern, Yale-Myers Forest, Union, Connecticut USA

Conducted and planned five timber sale preparations, silvicultural research, Christmas tree management, post-harvesting inspections and public education. Instructed summer graduate workshop for Yale School of Forestry and Environmental Studies on vegetation measurement and sampling procedures.

1988-1990 Extension Forester, U.S. Peace Corps, Guañacaste, Costa Rica

Developed and coordinated an 11,000 hectare regional windbreak project. Conducted project planning, promotion, silvicultural operations and field research. Planned and implemented forest inventories and management operations for ecologically sensitive areas. Established and maintained eight tree nurseries. Supervised and implemented an urban reforestation program.

1989-1990 School Refurbishment Program Representative, U.S. Agency for International Development, Guañacaste, Costa Rica

Performed eight community evaluations to determine project feasibility, follow-up site visits and project liquidation.

1982-1988 Front Line Supervisor, U.S. Army National Guard, 112th Medical (Air Ambulance) Company, Bangor, Maine USA

Served as crew leader for a five man helicopter repair team. Supervised and coordinated crew training, administration and maintenance of UH-1H helicopters. Honorably Discharged. Rank Sergeant.

1987-1988 Reconciliation Assistant, Liberty Mutual, Inc. Boston, Massachusetts USA

1986-1987 Forest Technician, Lavally Lumber, Inc. Sanford, Maine USA

1985 Arborist, The International, Inc. Bolton, Massachusetts USA

SPECIAL SKILLS AND PROFESSIONAL ACTIVITIES

Computer Skills: Have working knowledge of the following software languages SAS, SYSTAT, LIMDEP, GAUSS, LINDO, WordPerfect, MS WORD, WINDOWS, HARVARD GRAPHICS, FREELANCE, POWERPOINT, and EXCEL applications. Trained in Geographical Information Systems (OSUMAP and IDRISI).

Language Skills: Fluent in Spanish, both written and spoken; limited abilities in German.

Professional Activities: American Economics Association, Society of American Foresters, and Forest Farmer Association.

PUBLICATIONS

REFEREED (JOURNALS)

Amacher, G.S., Cruz, W. Grebner, D.L. and W.F. Hyde. (1998) Environmental Motivations for Migration: Population Pressure, Poverty and Deforestation in the Philippines. *Land Economics*. 74(1): 92-101.

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MANUSCRIPTS SUBMITTED TO REFEREED JOURNALS OR IN PREPARATION FOR SUBMISSION

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BOOK CHAPTERS

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OTHER PUBLICATIONS

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PROCEEDINGS AND PRESENTATIONS

Amacher, G., Aust, M., Grebner, D., Groninger, J., Shabman, L., Sullivan, J., and L. Zepp. 1996. "Landowner's financial returns to reforestation of marginal farmlands in the Mississippi alluvial plain: estimates, interpretations, and policy implications." Paper presented "Connecting points of view in the Delta, Jackson MS, August 14-16 1996.

Bigsby, H. and D.L. Grebner. 1996. Forest resource accounting: implications of forest management strategies on national accounts. Presented at Southern Forest Economics Workshop, Gatlinburg, TN, March 27-29, 1996.

SPECIAL REPORTS

Grebner, D.L. and C.R. Hatch. 1994. Review of forestry planning and development project: government of Pakistan -- United States Agency for International Development. *Special Report to Winrock International.* 40 pp.

Grebner, D.L. 1991. Evaluation of growth & yield models for tropical rain forests. *Preliminary report to Harvard Institute of International Development.* 25 pp.

AWARDS AND HONORS

1995 Fulbright Scholarship, Lincoln University, Canterbury, New Zealand

1987 Graduated with High Distinction from the University of Maine

1986 Alpha Zeta Distinguished Maine Chapter Member Award at University of Maine

1985 Robert I. Ashman University of Maine Forestry Summer Camp Award

OFFICES ELECTED OR APPOINTED

1996-97 Chairman of Graduate Student Association Regranting Board at Virginia Polytechnic Institute and State University. Facilitated the small grant, annual and contingency funding programs along with managing the $44,000 budget. The purpose of the board is to redistribute all funds to Graduate Student Organizations at Virginia Tech.

1996 College of Forestry Representative of Graduate Student Assembly at Virginia Tech

1994-95 College of Forestry Representative of Graduate Student Association Regranting Board at Virginia Tech

1991 Student Representative to Faculty Search Committee at the School of Forestry and Environmental Studies, Yale University.

1990 Yale Forestry Club Officer

1986 University of Maine Chapter Xi Sigma Pi (Ranger)

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