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Logging Cost and Productivity Associated with Labor and Mechanization in the Eastern United States

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By

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Forty-eight harvesting contractors over 13 state submitted data on cost and production over a period from 2003-2006. Within this group, 30 harvesting contractors submitted data for all four years in the study period. Discussions of logging development is presented in Chapter II focusing on labor and equipment. Data analysis focused on production estimates and cost information from a firm size and regional standpoint in Chapter IV. Analysis of consecutive data in Chapter V focused on shifts over time in labor, equipment and related cost categories. Contractors in the Coastal Plains were most numerous and demonstrated a distinct difference in sub-groups. Piedmont firms were second in number followed by Appalachian and Lake States firms. Consumables costs affected all firms most especially between 2004 and 2005. The number of medium sized firms dropped sharply in 2005 indicating attempts to either reduce operating costs or spread increased operating costs over higher production levels.

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CHAPTER I

INTRODUCTION

1.1 Background

The current wood supply system begins with a stand of timber, typically owned by private landowners, and ends once final products are delivered to and bought by consumers. With a large investment in depreciable machinery and relatively low amounts of capital invested in inventories and real property, independent contractors businesses are the link between supplier (landowners) and producer (mills) and, ultimately, consumers. These businesses not only contribute greatly to local and state economies but are typically family enterprises. It is not uncommon to see a father and son or brothers maintain daily harvesting operations with the support of mothers, wives and/or daughters who are responsible for keeping adequate records and sometimes maintaining proper relationships with timber buyers and mills. Although their importance to the economy cannot be denied, there is also a social responsibility inherently associated with contract harvesting, more commonly referred to as logging.

Modern contractors are business people. Most all have diplomas and have acquired the knowledge needed to become a successful entrepreneur through years of experience in the industry. Others have college degrees in forestry, engineering or business and some even maintain staffs consisting of lawyers, insurance specialists and, in some cases, foresters (Stuart, et. al., 1996). Regardless of their location, age, education level or appearance, the independent harvesting contractor, known henceforth as a logger, is generally a person who knows the most cost effective and efficient way to get a tract of timber from stump to mill.

Both the volume and value of timber harvested has increased substantially but it seems that loggers are not gaining their fair share of the increase (Stuart and Grace, 1998). With such a high investment in mechanization which depreciates in a short time span as well as exposure to risks such as weather, loggers are entitled to what they have worked to obtain. In order to enhance and, at the bare minimum, maintain the current position of logging, several of the artifacts and attitudes toward this profession may need to be rethought if not completely removed from the system.

1.2 Objectives

There are two main objectives of this study. First, the database previously created through this project needs to be maintained as a source of reliable information for researchers to continue monitoring the logging industry. Secondly and more specifically, this thesis will work to expose the economic impact that logging has on local and state economies and also the role that labor and equipment play in cost and production levels.

CHAPTER II

LITERATURE REVIEW

2.1 Overview

Independent harvesting contractors are the "action components" of the wood supply system (Stuart, Grace and LeBel, 1994). Current wood supply systems have evolved in response to political, social, and economic change in the areas where they function. Evolution continues and, as with any evolutionary process, the forces that shaped the current system are still at work. Loggers are currently operating in a system that is laden with artifacts from past business ideas, practices and relationships (Stuart and Grace, 1998) making it difficult to attempt a new, perhaps more efficient, method or practice that the present system is incapable of or inefficient at handling.

Social change had a huge impact in the eastern United States in general and the Gulf South in particular. It has been less than 250 years since the first invasion of settlers into the forests of the Mid South region, but in that time most of the region has been harvested and reforested at least four times, with periods of agricultural use between rotations (Davis, Thompson & Richards, 1973). None of the other major forestry regions have undergone such a large change at such a rapid pace. Labor and machines have been steadily present through the development of the forest industry, but the type of each as well as the methods and means of harvesting, delivering, and processing timber has followed the changes occurring in large society. These changes, like most technological and social changes, tend to occur in a stepwise fashion and four epochs have had the largest impact on the current system.

The wood supply system of the region started as an informal, labor intensive activity during the colonial and pre-Civil War era. The turmoil of the Civil war and Reconstruction resulted in transformation into a capital intensive, industrial undertaking. The system reverted back to a dispersed, labor intensive form in the early 20th century with the cut-out of old growth and the Great Depression. Social, economic, and market changes in the post World War II era finally led to the development of a capital intensive private entrepreneurial structure.

Throughout these eras, the public perception of the forest changed as well. During the settlement era the forest was a barrier to more intensive land use and an economic resource that could be exploited by those willing to take the risk and endure the privation of living beyond the margins of civilization. In the post Civil War era, the forest was the economic resource that could restore the economy of the region, bringing investment to southern states and providing employment for displaced agricultural workers. The Kraft paper industry evolved in the first decades of the 20th century and the internal combustion engine was transformed transportation. The post WWII era saw rapid social change with the civil rights movement, the construction of the interstate highway system, and increased employment for rural workers. These forces have been discussed in detail elsewhere; therefore this thesis focuses on their effect on the technological, economic, and social structure of the wood supply system.

2.2 Settlement Period

Both agricultural and forestry activities were subsistence in nature when settlers first entered the area and each relied on the existence of the other. Clearing timber was necessary before land could be put under the plow and timber provided off season work and secondary income for farm owners and labor. Wood was the primary material of the time. Homes, barns and sheds, fences, furniture, tools, utensils, boxes, barrels, fuel, and fertilizer along with the other amenities of life were products of the forest or by-products of forestry activities (Stewart, 2004). In areas such as the prairies of the black belt and the Great Plains where the native vegetation was grass rather than forest it has been shown that most settlements "sprang up" where forests met fields (Sanders, 2001) and settlement beyond these border areas was restricted by the scarcity of wood. Everyone had to be proficient at common, daily tasks. Some may have taken up a specialized skill or service that could not be provided by the common person but these specialists were still involved in normal agricultural and forestry activities.

Two factors were responsible for the evolution of logging into a separate activity during the settlement period. The first factor was that early settlements concentrated on the most fertile soils or locations that provided a good medium for crop growth and easy transport to domestic and international markets. The less fertile and accessible areas remained in forest and were held in public ownership, given as land grants to individuals, or sold to speculators. Since these ownership groups were largely unable to control use of their lands, these areas were treated as commons for hunting, trapping, and grazing by the local populace and adding timber harvesting to the list was a small step. Legally, in colonial times, all timber was reserved for the crown but practically, the land was useless if timber was not cut. Settlers saw logging as an opportunity to get cash to gain title to land and/or elevate their status in their community (Stewart, 2004).

The second factor was the value that forest products held. The colonies, like their inhabitants, needed income to survive and wood products had value in trade. Consequently very little or no local restrictions were placed on the logging and milling labor force (Moore, 1983). Mills were welcomed under French and Spanish rule of Louisiana and both countries allowed lumbermen to cut on public domain. Spain, however, did not grant title of the land to the harvesters like the French had done.

In its early stages, commercial (as opposed to land clearing) timber harvesting was a seasonal activity "undercapitalized, labor intensive cottage industry performed by a cadre of full-time employees supplemented by a pool of off-season agricultural labor" (Stuart, et. al., 1996). Harvesting and transporting wood was the domain of those lacking sufficient capital to buy into an agricultural endeavor. It was a way for a "poor man" to amass the resources necessary to buy land, livestock, and slaves to move into the propertied class. It was also a young man's undertaking that required few resources other than hard work, a sense of adventure, and a willingness to spend time away from family and society.

Longer growing seasons in the South meant that labor was relatively more expensive but supplementing farm wages with forest income kept labor fairly stable. However, when this was combined with capital investment in labor and the slave class being virtually immobile, technological advancement and out-migration into urban economies was unrealistic (Earle and Hoffman, 1980). Manufacturing forest products - sawing lumber, cooperage, boat building etc. - became separate economic undertakings supplying specialized markets but harvesting was still an activity capitalizing on available land and a secondary application of workers from seasonally intensive agriculture. Loggers cut timber for a variety of products such as quality lumber for export and fuel wood used domestically but they were still linked closely to the land by agriculture (Stewart, 2004).

Technology is defined by the American Heritage Dictionary as the application of science especially in industry and commerce. Technology available to the labor force of the colonial period was very simple. The tools were basically those brought by European settlers that could be manufactured locally. Advancement in the settlement period of the 18^{th} century was accomplished by either altering these simple machines such as redesigning ax heads or handles, or by adapting animal transport to the different soils and topography and applying different business practices. Topographic relief provided few opportunities for the use of water power in sawmilling. Steam engines were starting to be used in saw mills in the closing years of the era but in-woods operations still relied on human and animal power for harvest and transportation.

2.3 Antebellum and Civil War Period

Family and slave labor constituted the majority of the labor force through settlement and into the era just prior to the Civil War. Some entrepreneurs employed a mix of wage and slave laborers to harvest timber from the interior and float it down river to feed coastal mills and foreign markets but this was a relatively unseen and unnoticed component of the overall labor force. Tobacco and indigo cultivation continued but cotton became a major cash crop and increased the labor supply, thus lowering its price, due to a major influx of slave labor. These plants required intensive culture and the technology to mechanically plant and harvest was lacking. Even if it had been available, the capital required to invest in this type of mechanization could not compete with slave labor and land investment. Capital substitution for labor was not impossible, but impractical. If capital resources were to be added to the system, it would have to be added from outside investors.

With the onset of the Civil War, much labor was taken away from both agriculture and forestry. Younger white males enlisted or were drafted and went off to war. Slave labor remained but was sorely needed to maintain the agricultural base. The effect of the war was not felt to its fullest extent until the southern United States had to rebuild itself, physically and economically. The labor force changed dramatically as a result of abolition and went from family and slave labor to family and wage labor which in time evolved into sharecropping. The war changed the international cotton market by decreasing global supply and southern growers that supplied Europe before the war found themselves in competition with growers in Asia and Africa. Americans crossed the Mississippi and spread into the Great Plains, an area well suited for beef and pork production with better transportation links to the East Coast thus diminishing the demand for southern livestock. Southern agriculture was in no position to supply economic relief to the area because much of the capital of the area, both human and financial, had been destroyed by the war (Williams, 1989). The forests of the region held vast amounts of a resource that could be exploited and unskilled labor to exploit it was abundant but the realization of that potential required capital. The southern United States, just as it was before the war, was basically a market that needed a stimulus before it could develop.

Two technological advancements of the time that spurred the development of logging, and indirectly provided capital for the region, were the steam engine and commercial railroad system. The steam engine had found limited application during the late Ante-Bellum period in powering boats on the rivers and as fixed power supplies for gins and sawmills. Transport applications of steam power required that the vehicle size be capable of accommodating the engine and its water and fuel supply, limiting it to boats and rail applications. Size, cost, and fuel requirements eliminated its use as an in-woods machine until 1885 when the Bessemer process of refining lowered the cost of steel and improved quality, providing the reduction needed to incorporate them into logging operations. This new method of refinement also allowed for the replacement of the ax with the crosscut saw as well as the development of circular and band saws in mills. Portable power coupled with the development of wire rope by Roebling led to the "steam donkey" in 1882 and cable yarding systems (Wilma, 2003) which was the first advancement for in-woods operations, increasing productivity and size of operations, while narrow gage railroads extended their reach.

2.4 The "Big Mill' era

Railroads provided a two-fold benefit for the southern forest industry. The area was in dire need of economic as well as physical reconstruction, and needed products that would provide capital, employment, public services and other forms of encouragement for the recovery process. The forests of the northeast and the Lake States were beginning to cut out in the late 19th century, opening the way for other, less well known species to enter the market. Southern yellow pine timbers were well suited for the sills of railcars, and the lumber, because of its strength and resistance, was equally well suited for building freight and passenger cars (Williams, 1989). Other southern pines were useful for bridge and trestle construction, and southern oaks served well as ties. The timber was attractive for use in the North and West but the rivers, which were the primary transport medium for timber at war's end, flowed south. Most agricultural crops in the region such as grains and cotton were seasonal and could not supply the year around demand necessary to offset the cost of building and operating rail lines but timber and lumber were products with year round production and demand, if transport from the forest to the mill was not dependent on floating. Large, publicly held railroad companies operating standard gage equipment were built to join the region with the rest of the country and smaller, narrow gage, privately owned railroads joined steam powered sawmills with their raw material supplies, ultimately satisfying two needs. Mid-western lumber brokers and wholesalers were willing to provide the capital necessary to buy land and timber and build large steam driven mills while the railroads were anxious to develop new markets for their services. The first industrial scale forest industry developed.

The mainline railroads used the conventional standard gage "rod engines" with power supplied by a pitman rod joining the steam cylinder and the wheels. This arrangement was heavy and bulky, but struck a reasonable balance between tractive effort and speed. The roadways were considered permanent and could justify the investment in roadbed, track, alignment, and other dimensions necessary for fast bulk transport. Logging railroads were considered temporary, requiring only sufficient road bed to keep the route serviceable during wet weather until the timber was cut out, and minimal investment in track. These narrow gage woods railroads, where tractive power was more important than speed, turned to smaller, lighter, gear driven engines where the steam engine was a separate unit joined to the wheels through a gear box and drive shaft.

Railroad logging originated in the North and Lake States, and the equipment and technology came south with the industry. The machine appearing most often on southern logging railroads was developed in the mid-1870's by Ephraim Shay (Hoffman, 1999) although a considerable number of the competitive Climax and Heisler engines were used. Buyers of the Climax brand could select from three types of wheels for the engine, ones that ran on steel rails, wooden poles, or both. The logging railroad could arguably be considered the first advent of mechanization in timber harvesting, replacing human and animal power in skidding and loading to market. From stump to railcar, however, still relied on draft animals and men.

Skidding, moving the stem of a tree from where it was cut to a point for transport, had been the domain of human and animal power since Biblical times. The first wave of industrial scale logging in the Northern and Lake States had an advantage that the South did not. The ground froze for a quarter of the year or more providing a firm travel surface and layers of snow or ice further reduced friction. The southern soils didn't freeze, and while the sandy soils were traversable year around, the clay and loamy soils turned into muddy bogs during the winter months when rainfall tended to be the heaviest. Oxen were favored over mules and horses during the winter months because they were less likely to "bog down" or break a leg in the deep mud. Mules were favored over horses where soils permitted. Like oxen, mules were better adapted to the hot climate and weak soils.

The advent of the steam skidder changed in woods skidding. Steam hoists, a winch attached to a steam engine, were being developed to handle materials at wharves and in factories and this technology was soon adapted to in woods operations. The steam skidder consisted of a steam engine and large winch mounted on a rail car (Drushka and Konttinen, 1997). Most were “High leads”, equipped with an integral boom or spar that raised the winch line well above the ground. The line with the butt rigging, the means of attaching it to a stem or log, was hauled into the cut-over area by a lighter line called a re-haul or by a horse or mule. The line was attached to the log or stem, and the winch line tightened pulling the material to the landing area adjacent to the forest rail road. These “high lead” skidders could move wood from a band roughly 600 feet wide on either side of the railroad. The resulting spacing of spur lines 1200 feet apart became common forest road spacing that was maintained long after the steam skidders were retired.

Loading the material onto a vehicle for movement where steam power was lacking was usually done by hand or by “cross hauling”. Poles were laid with one end on the ground, the second on the carrier and the material rolled up and onto the vehicle. Manual loading usually was done with a canthook or peavey, a simple lever with a hook on one side. In cross hauling, both ends of a hemp or wire rope were tied off to the carrier, the resulting loop passed under the log to be loaded, across the top of the load to a team or yoke of oxen on the other side. The animal then walked away, perpendicular to the carrier, tightening the rope, which caused the log to roll up the ramp and onto the vehicle (American Forestry Association, 1931). The advent of the steam loader speeded the process up and made the job much safer.

The Barnhart loader was developed by Henry Barnhart, one of the partners in the Marion Steam Shovel Company at the suggestion of Frank Goodyear, one of the founders of the Great Southern Lumber Company of Bogalusa, La. The machine was basically a steam engine and a winch mounted on a pivoting base equipped with a short boom and, the loader traveled along the top of empty logging railroad cars under its own power. A set of log tongs attached to a winch cable passing through a pulley at the top of the boom would be placed on a log to be loaded at its center of gravity. As the winch line tightened, the log was dragged to the side of the car, lifted, and swung onto the load. A "top loader" positioned the log on the load, unhooked the tongs and passed them back to be set on the next log. When the last car on a train was loaded, the loader moved onto a service car and waited there for the next train.

The steam skidder, the steam loader, and the narrow gage gear drive locomotive combination was the first adventure in mechanized harvesting. The steam engine was too heavy and bulky to perform the labor intensive jobs of felling, limbing and bucking necessary to prepare the stems for transport. This first level of mechanization was limited to those jobs where sufficient volume was available to justify the cost of building railroads to serve a single mill. Smaller operation, harvesting small tracts, and cutting smaller timber still relied on the manual/animal techniques of the past.

The fifty years between the end of reconstruction in 1877 and the beginning of the Great Depression were boom times for lumber production in the Gulf South. The timber, both yellow pine and southern hardwoods, was plentiful and available and the expansion of the country into the treeless Great Plains coupled with the ability to economically transport material northward opened a wide range of markets. Labor, albeit largely unskilled, was available and in need of employment, and the states, suffering from the loss of agricultural markets and assets during the war were in search of other resources to re-build their economies.

The boom opened up the interior of the state and newly placed sawmills resulted in a large number of mill towns scattered throughout the piney woods and the delta. Other, larger cities such as Hattiesburg and Laurel, in Mississippi, developed as commercial centers. The railroads serving the sawmills also served other communities along their routes, stimulating further development. Lumber production increased to levels that were not achieved again for another 70 years but boom times are impermanent. The need for economic development was so great that little thought was given to what would happen when the timber cut out. The Northeast and the Lake States went through the cycle twenty or thirty years prior to the south and could have served as an industrial and political template, but their fate was largely subsumed in efforts to capitalize on the opportunity available and rebuild southern economies.

Several forces came together during the 1920s that were to have a major impact on the region and state. The available timber was becoming increasingly remote and difficult to harvest. The Far West became the area of national expansion and with settlements being much closer to the forests of the Northwest, the demand for southern timber decreased (Williams, 1989). Slowly, one by one, the large southern mills began closing, a process that was to accelerate in the next decades. Some companies followed the timber west, many moved into other ventures in the region, and some simply shut down. Some communities like Hattiesburg and Laurel survived. Others like Electric Mills and Norfield vanished, almost without a trace.

A core group of forest owners were concerned with the future. There was a movement during the boom times to look for more profitable markets for sawmill residues than simply boiler fuel and pulp and paper held great promise. Dr. Charles Herty, a pioneering chemist in the turpentine and naval stores area, was a leading advocate for the use of second growth southern yellow pine for producing mechanical pulp for newsprint (Reed, 1982). The kraft or sulfate pulping process, brought to the south at the turn of the century, produced a very different paper suitable for making paper bags and containers. The second kraft mill in the country was built at Moss Point by J. L Dantzler as a market for residues from the company's sawmills.

The naval stores industry was under pressure from two different sources: the harvest of the old growth timber was reducing the stock of timber available to produce resin and the expansion of the petrochemical industry, developing as a result of the increased use of internal combustion engines, was eating into the markets for their products. The declining supply of standing timber was countered by a transition to destructive distillation processes using stump wood and by products of the Kraft pulping process. Recovering and shipping stumps became an adjunct to conventional harvesting; one requiring different approaches and tools (including dynamite) (Outland, 2004).

The internal combustion engine came into its own and began replacing steam engines in mobile applications, especially as replacement for horse drawn vehicles and for field applications. The advent of the automobile increased the demand for more all weather roads, displacing the narrow gage railroad as a means of transport from forest to mill.

2.5 Depression and World War II

Labor and technological development continued until the market crashed in 1929. The transitions to different technologies, products, and methods of operation had started during the "Roaring Twenties", but were overshadowed by the Great Depression. Agricultural and forest industries were beginning to lose employment in 1929, but the market crash accelerated the process. (Bernstein, 1997). Alternative employment for the rural labor force, largely unskilled and sometimes undereducated, was limited.

It is generally accepted that as a country develops, their dependence on natural resources provided by agriculture and forest activities decline, turning toward manufacturing and service industries. But the process is not pretty or humane. The United States seemed to be developing rapidly in the 1920s, but was unable to sustain the "new" economy. The country attempted to fall back on its natural resources sector following the crash, but the capital shortage triggered by the crash was once again the limiting factor, especially for the south. The nation, and the south in particular, ultimately reverted back to a more modern version of its subsistence structure of early settlement.

The problem was one of market and capital availability. The boom times in the lumber industry generated a lot of economic activity, but the capital financing the industry came largely from outside the state and region. That money was either lost in the market collapse or pulled from the system before the economic fall. The infrastructural improvements remained, but the capital needed to recover their status prior to the crash, or to upgrade and expand them was lacking. Those industries that saw increased net investment through the 1930s were not sufficient to absorb the amount of labor that remained idle (Bernstein, 1997). By 1935, however, the industries hit hardest by the crash that were slow to recover immediately following market failure, namely forestry, agriculture and mining, were the industries that absorbed displaced labor because all the natural resource industries could revert to labor intensive methods when wages dropped, therefore causing capital substitution for labor to swing toward substituting labor for capital.

Forest ownership and operations are both, by nature, rural activities (Stuart, 1996) and are seen only by those individuals directly involved in them. Both agricultural and forestry activities are basic components of most rural societies and these activities take on some of the connotations associated with a rural lifestyle (Brown and Zuiches, 1993). Kennedy and Thomas (1996) relate that rural societies are "often seen as more simple, less diverse and less sophisticated . . . putting them at a comparative economic disadvantage." Urban populations sustained their existence during the Depression era but their lack of resources to fall back on to provide even a subsistence level of existence placed them on the same footing as the poorest members of rural societies.

The logging industry of the depression era retained some of the technologies of the boom times, especially the cross cut saw and improved axes, but slowly moved away from steam skidders, steam loaders, and narrow gage railroads which required large capital investment. In-woods transport reverted to animal power and loading the smaller logs could be done by hand or cross hauling. Light trucks traveling on public roads displaced logging railroads and lumber was produced by portable mills in the forest as rough, green lumber moved to centralized drying and planning mills. Pulpwood was moved by animal power or light trucks to rail sidings or woodyards. Other products of the era, stave bolts, cross ties, etc were of a size that could be readily handled by manual or man/animal methods. The wood supply system shifted from being defined as an integral part of the manufacturing process to a stand alone entity. The emphasis shifted from increasing the performance of large, corporate, systems to maintaining a sufficient number of smaller operations to meet the demand while keeping operating costs low.

The economic and cultural changes facing the southern states during the depression years were particularly challenging. Out-migration was difficult because of race and cultural prejudices left in place by the Civil War. The individual who valued rural life was likely to stay close to home and family where they could find support and provide the necessities of life by small scale farming and outside employment. Those finding local employment tended to value their jobs, likely increasing their productivity, and even though wages earned may not have been as high as job opportunities in the North, the worker was familiar with the rural setting and lifestyle, where the job only played a part in overall satisfaction. When these factors were coupled with the forest resource and potential of the lumber industry, woods work was a viable means of surviving the Depression.

The industry, having a readily available work force at relatively low cost saw limited need for technological advancement in an adverse economic climate. The challenge of the depression was finding work for those in need. Federally sponsored programs such as the Civilian Conservation Corps (CCC) and the Works Progress Administration (WPA) provided jobs for those otherwise unemployable. One process that the federal government employed to relieve landowners from tax burden took tax delinquent cut over land back into federal ownership as National Forests and employed the CCC to get it replanted. The WPA was used to improve the public road system and stimulated technical advancement by shifting from railroad to motor vehicles.

The big mill era had left a countryside dotted with small mill and agricultural communities amidst the recovering forest and the infrastructure to support them. When the South is compared with eastern Canada or Scandinavia, three regions relying on forest activities for economic stability and growth, only the southern United States had growth rates to reforest the region quickly, a large population of willing workers living in the forests, and advanced infrastructure existing within the stands of timber that were available for harvest (Stuart, et. al., 1996). The additional cost of logging camps, and the additional wages necessary to lure young, able bodied men to employment in a remote setting was not needed. Low direct and indirect labor costs had a large effect on the ability of the forest and lumber industries to survive and recover, albeit with a different structure.

World War II had a huge impact on the logging industry. Where the Civil War spurred development through elimination of competing products, WWII created new markets for labor, provided the economic boost that the United States needed to recover from the Depression and brought about the changes needed to develop the next wave of mechanization in logging. Previous barriers to out migration from the South were lowered and workers of both races moved to war production industrial employment in the North and West (Holley, 2000).

Wood, in all its forms, was a valuable war time material with a national demand. Rudimentary efforts at mechanization were undertaken to find ways to meet this demand with a smaller and often older work force. Machines like the Taylor "Loggers Dream" a truck mounted cable yarder introduced in 1937 found a ready market) but the war time economy and its demand for military equipment restricted the amount of mechanization that could take place in other industries. Many of the advances of this era were simple adaptations of devices previously tied to steam power for use with internal combustion engines such as farm tractors and light trucks.

2.6 Post WWII

Perhaps the most innovative and exciting era, certainly in mechanization, came at World War II's end. The war had drawn much labor into the northern factories, creating a labor void of skilled forestry workers that needed to be filled. Returning service men found the southern region inviting and returned home, bringing with them knowledge of diesel power, hydraulics, welding and other mechanical skills gained during the war that could be incorporated into machines to be used for logging (Drushka and Konttinen, 1997). The end of the war also resulted in surplus military equipment, especially light crawlers, 4x4 and 6x6 trucks, coming into the market. In addition many veterans used at least some of their benefits to invest in farm tractors. Like the ox or mule, they could be used in woods work during the off season. The increase in farm tractors between 1940 and 1950 in the mid south states outpaced that of other sections of the country.

Table 2.1 Farm tractor sales in the southern US; 1940-1950.

South	1940	1950	Gain	%
Alabama	7,638	45,751	38,113	599.0%
Florida	2,661	6,125	3,464	230.2%
Georgia	9,327	60,269	50,942	646.2%
Louisiana	11,927	35,735	23,808	299.6%
Mississippi	10,577	51,698	41,121	488.8%
Texas	98,923	232,328	133,405	234.9%
Total	142,993	433,856	290,853	303.4%

North	1940	1950	Gain	%
Illinois	126,069	234,798	108,729	186.2%
Indiana	73,221	153,980	80,759	210.3%
Iowa	128,516	240,941	112,425	187.5%
Kansas	95,139	146,266	51,127	153.7%
Nebraska	70,761	127,154	56,393	179.7%
New York	58,906	119,302	60,396	202.5%
Ohio	89,999	182,481	92,482	202.8%
Pa.	54,842	125,851	71,009	229.5%
Total	697,453	1,330,773	633,320	190.8%

Lumber production in the south declined in the immediate post war years, but the demand for pulpwood increased and the pulp and paper industry was undergoing major expansion. The industrialization of the South that started with war time production continued as a result of civilian post war demand and since capital was again available and relatively cheap, strategies for producing more volume with less labor began to emerge in the US, Canada and Scandinavia. There were attempts at using a base machine and several different attachments to convert tractors used in small farm agriculture to logging, but these met with limited success. The mechanization strategy adopted in forest harvesting was based on the advancements in large scale agriculture, mining, and construction with machines specialized for one function (Stuart, et. al., 1996) and would be adapted to meet different species, geography and wood use practices.

Harvesting became an entrepreneurial, rather than company, activity in the 1940's and was becoming more mechanized by the beginning of the 1950's. Independent contractors' efforts turned to maximizing the production of available labor through technological advancement rather than increasing labor supply or disposing of it with increased technology since labor productivity was, and still is, bound by the level of technology available to it. The move toward mechanized harvesting in the 1950s was a balancing act between reduced labor supplies and the persistent scarcity of capital. Capital was introduced into the system as necessary to make the best use of labor available (Stuart, et. al., 1996).

The mechanical advancements in all parts of logging operations underwent huge changes. The first advancement using technology to capitalize on labor was the chain saw in the early 1950's. It was a small two cycle engine fitted with a flat steel bar carrying a chain with teeth on the exterior offering a way to reduce effort and increase productivity per man day (MacDonald and Clow, 2003). European firms, Stihl and Dolmar were producing gasoline powered saws prior to WWII whereas American manufacturers were producing electric saws operating from a tractor mounted generator. Three innovations were necessary before the saw could achieve wide acceptance. Improved aluminum casting and machining would cut the weight of the engine and the carburetion system needed to be adjusted to function in a vertical or horizontal position. Finally the development of the "chipper chain", an improvement over the earlier "scratcher" chain design, cut the amount of time the saw was used on one stem. Although the saw increased labor productivity in felling, limbing, and topping timber, the job remained strenuous and dangerous.

After the invention of the chainsaw, differences in mechanization approaches in Canada, Scandinavia, and the US South began to appear, diverging on stump to roadside transportation. Northern countries had been affected by the Pleistocene Ice Age and were rolling or hilly, dominated by large boulders left behind as the glaciers melted with forest operations being remote and deep in the interior. Forwarding, loading a maximum amount of wood on a carrier to reduce drag and assure maximum volume movement on longer hauls was favored.

Sweden, the industrial center of Scandinavia in the immediate post war era, had remained neutral during the war and emerged with its manufacturing capability intact, focusing on manipulation of farm equipment that could be used by landowners to harvest woodlots during the off season. These worked relatively well in southern Sweden, but industrial forestry was moving north and further inland to areas remote from towns and cities. Forest operations often had to carry both the direct wages of the forest workers and the indirect cost of providing housing and food for both men and draft animals. These overhead costs provided additional stimulus for increasing labor productivity. One important Swedish innovation of this era was the small, three section, hydraulic crane or knuckle boom loader that could be mounted on a farm tractor or truck. The tool was especially useful for picking up wood in the forest and piling it at roadside for scaling and truck hauling.

Canada had developed a strong heavy equipment industry as a result of its wartime role and the attendant expansion of the mining sector. Much of the available forest lay well north of the centers of population in rough, glaciated lands with few roads. Logging had traditionally been done with horses moving wood to stream side and floating it out with the spring thaws. The remoteness of the forest required that both the men and animals involved in logging be housed in camps. Logging costs included the cost of housing and provisions as well as the direct costs of labor and equipment. The industrial tempo of the post war era could not depend on a once a year delivery of large volumes of wood, and looked to a more consistent flow of wood by truck. Consequently equipment development focused on heavy duty, off road, wheeled carriers that could travel into the forest and bring out large volumes per trip. The Dowdy Forwarder was developed as a prototype by the Pulp and Paper Research Institute of Canada and was the benchmark for other pieces. The Mark II, built by Bonnard Equipment Limited of Lachine, Quebec in 1951 introduced the idea of articulated steering (Drushka and Konttinen, 1997), where the axles are affixed to the frame of the machine which is hinged between the axles and steered by changing the relation of the frame sections one to the other. Although it was still unreliable and unrefined, it introduced an idea that would be used in the machines that followed it. The Mark III and IV introduced a load carrying bed behind the cab that combined a tractor and semi-trailer into one machine, eliminating the direct mimicking of the horse and jumpsled and redefined the "paradigm of forwarding." (MacDonald and Clow, 2003). Although the innovation of a replacement for the horse had been realized, it still lacked certain components. Since felling and piece preparation was still a manual task, an expensive piece of equipment was restricted to waiting on a manual activity. The addition of a knuckleboom grapple loader to the bay of the forwarder, by Dowdy Equipment ultimately allowed the machine to move both 4 foot and 8 foot sections of wood. This not only eliminated the chance of "half loads" but also reduced the time the woods crews spent moving and piling wood by half. The forwarder was a huge step in logging, but it did not change the production process. Trees still had to be felled, limbed, topped and cut to product length at the stump just as they had been in the horse and bobsled era.

The southern United States was quite different both in terrain and transport to roadside. The dominant forest areas of the South were on unglaciated terrain that was flat or gently rolling with an alluvial micro terrain. In-woods transport distances were relatively short because of the public road system and roads or roadways left behind by previous land uses. Skidding, picking up one end of a stem and dragging it to roadside was favored in the South where soils had less bearing strength and the transport distance was short. Pulpwood became a major product in the post war era as a result of the booming kraft paper industry, and a "system" of preparing the wood (felling, limbing, and cutting into 5'3" bolts) at the stump for pick up by six wheeled, over-the-road trucks (Bobtail trucks) equipped with a skeleton bed for delivery to a local rail wood yard developed. The system was effective for harvesting stands of young timber and capturing the material left behind by sawlog operations. T. Z. Brown of Louisville, Mississippi developed the "Big Stick" loader which was a simple swinging crane arm and light winch mounted on the truck to speed loading. Lucian Whittle of Brunswick, Georgia developed the "pallet" system. The operation was equipped with open top U shaped pallets formed of heavy pipe and angle iron that would hold about 1 ½ cords of pulpwood. A "tilt fork" truck, a six wheeled older truck restricted to off road travel equipped with a cable operated tilting L shaped fork behind the rear axle would carry the pallets into the cutting area for loading. The pallets were lowered to the ground, reducing the height wood had to be lifted by about three feet, reducing and speeding the loading process. When the pallet was full, it was taken to road side and set out for pickup by a three or five pallet truck for delivery.

Farm tractors being used for woods work also saw innovation. The Ferguson hydraulic system, pioneered by Henry Ford and Henry Ferguson in the late 1930s, provided a method of raising and lowering the drawbar from the tractor seat. This capability found quick application in the forest. Trees could be felled and limbed at the stump and skidded tree length with a farm tractor to roadside for bucking to length and loading. A two wheeled “arch” behind a small crawler or farm tractor was used for sawtimber. Tree length operations reduced in-woods activities to felling, limbing and topping and changed the overall process of timber harvesting.

The farm tractor, designed for use on prepared fields, was not well equipped for in woods work, and the cost of operation of crawlers was high. Several approaches to developing a purpose built machine for tree length skidding were tried. There were a variety of firms that modified 4X4 and 6X6 military trucks for logging and others adapted Ackerman steer loader chassis for the woods but all were front wheel steer and had common faults. First, the wheels did not follow the same track in turns, making in-woods maneuvering difficult. The operator had to be concerned with the path followed by the steered wheels and the fixed wheels. Secondly, there was no good means of dealing with side to side terrain variability. The rigid frame on equipment such as this, lacking springs and shock absorbers, meant that if a wheel on one side went over a stump the rigid frame lifted the other wheel on that side free of the ground, allowing it to spin. Finally, power had to be passed through the steered wheels through universal joints. Transmitting power through universal or “knuckle” joints mounted at or near the steered wheel put maximum stress on these joints, and failures occurred in applications where shock loading was common.

These problems were solved with the development of articulated, or bent frame steered, machines. The frame of these were formed of two separate sections, one for the engine and operators cab, the second for the winch and arch for skidders or the rack for carrying wood for forwarders, joined in the middle by a heavy duty hinge at or near the midpoint between the axles. The machine is steered by hydraulic cylinders that vary the aspect of the two sections. This design allowed the use of rigid axles, eliminating the need for universal joints on the front axle, and allowed the wheels on the machine to follow the same track in turns. One axle could be cradled, pivoted at the center point to allow up and down movement of the wheels, or a trunnion tube installed in the frame hinge which allowed the two frame sections to twist one to the other. Articulated steering coupled with the development of the "logger special" tire with shredded wire embedded in the tread to resist puncture speeded the development of rubber tired skidders and forwarders.

The first popular skidder that sold well for an extended period was produced by KVP Timber Company and a local FWD Truck Company dealer named Archie Kerr in 1952 (Macdonald and Clow, 2003). It was a stripped down FWD truck with an A-frame and winch on the rear called the Blue Ox. In 1953, Bob LeTourneau introduced the Tournarch that employed the use of articulated steering accomplished by an electric motor and driven by the two front wheels.

The Blue Ox was simply a modified all wheel drive truck subject to all of the problems of transmitting power through a steering axle as well as the run in/run out problems in turning. The diesel-electric Le Tourneau avoided the problems of power transmission by mounting an electric motor at each of the two drive wheels, but was only two wheel drive, as was John Deere's efforts at modifying a small scraper, attaching a winch and fairlead in place of the pan. Articulated or bent frame steering had been tried in the past, but the forces required to steer the vehicle were too great for the manual steering of the time.

In 1958 the Garret Tree Farmer, a small but efficient skidder that used hydraulics for frame steering and movement of a front mounted blade was introduced. Manufacturing rights were later acquired by Canadian Car Division of Hawker Siddeley. Hydraulic steering was applied to a machine built by Timberland in 1961, when they switched from their rigid frame Timberskidder to the hydraulically frame steered, rubber-tired Timberjack (Macdonald and Clow, 2003). Early manufacturers were Garret (Tree Farmer), Timberline Ellicot (Timberjack), and Franklin. Other, long line manufacturers, John Deere, Cat, Taylor, Pettibone, and International Harvester soon followed. The potential market attracted companies such as Gafner, Hough (which became part of International Harvester), Gulf Engineering, Kenworth, Taylor Machine Works, Case, Clark and Massey-Ferguson, and Franklin to join in. By the mid 1970s there were 25+ firms manufacturing or marketing skidders, (Drushka and Konttinen, 1997). Although many companies were only present for a brief period, and most eventually turned to other product lines, Caterpillar, Franklin, and John Deere still maintain a large presence.

Already part of the agricultural equipment market, John Deere produced their first skidder in 1965, almost 130 years after producing the plow that gave the company its start. Four skidders were eventually marketed with the JD440 being the first. Subsequent models were the 540, 640 and 740 all designed to function with either cables or grapples (John Deere Forestry Equipment). In 1984, John Deere produced the 648D single arch grapple skidder which was the basis of the modern 638G III and 648G III models that are used by many contractors today.

Caterpillar based their skidder on their available knowledge in construction and earthmoving equipment. The 518 model wheeled skidder was introduced in 1971 and produced until 1996. The 525 was marketed in 1995 and the bigger model 545 was produced in 1999 (Nolde, 2000). Franklin's first prototype skidders were built by company founder Roger Drake and were light and mobile, very similar to the Garrett or Timberjack of the day. One thing that separated Franklin Equipment apart from other firms of that time was the attention they gave to the needs of loggers. A result of this attention was the Swamp Buggy built in 1965 to operate in southern wetlands. It was smaller and lighter so the machine was able to run on the vegetation and root mats below the water's surface but also strong enough to pull timber out of extremely wet conditions by utilizing 86-centimeter wide tires, specially designed by Goodyear for use on skidders.(Drushka and Konttinen, 1997).

The initial removal of tree from stump was the second task to see mechanization. When skidding technology began to advance a faster, more efficient felling process was needed to allow the new skidding technology to realize its full production. A prototype of Rudy Vit's feller buncher was introduced in 1957 as a solution to felling and skidding handicaps that were visible in an Ontario logging operation. Vit's machine incorporated chain saws and hydraulics mounted on a Bombardier HDW that cut the tree then laid it over the top of the machine on a rack at the rear. The machine may have seen much larger success had it not been introduced at a period when the focus of felling was on supplying the dominating pulp markets. Shortwood was preferred so Vit developed a second machine called the Bombardier Processing Unit in the mid 1960s that delimbed and bucked stems once they came to roadside. The interesting component of this unit was the incorporation of an electronic measuring system that calculated volume based on diameter and length (Kryzanowski, 2004).

The Buschcombine was the first practical demonstration of the ability to fell trees with a knife and anvil shear. The concept was modified by other manufacturers into a larger capacity shear that could be attached to the "C" frame of small bulldozers. The scissors shear with two blades that met in the middle followed and both were soon equipped with a grapple above the shear to hold the stem vertical after shearing and allow carrying it in that position to form a "bunch" for skidding. Next, the grapple was modified to allow grasping a second tree while retaining the first, allowing the machine to handle multiple stems simultaneously.

The necessity of reducing the stem to product length in the forest was being questioned. Some looked to ways for mechanizing systems that produced cut-to-length logs or bolts at the stump, others to ways for improving tree-length systems that delivered tree length stems to the roadside or manufacturing facility for further breakdown. The "Roanoke Rapids rail rate" arising out of an agreement between the railroads and the first Kraft mill in the south required that pulpwood be cut to 5'3" lengths to qualify for a preferred transportation rate. The importance of this rate advantage was disappearing as the industry began moving from a truck-woodyard- rail to mill transportation system to truck transport from woods to mill.

One of the first challenges to the American Pulpwood Association Harvesting Research Project, started in 1967, was to compare the relative advantages of the two fully mechanized systems of the time, the Buschcombine and Beloit. The Buschcombine, developed by Tom Busch of International Paper Company was a rubber tired, articulated carrier that used a shear for directionally falling a tree over a lift arm that fed the stem butt first into a chisel chain delimber. The tree was pulled through the delimber by 5'3" strokes, sheared to length and caught in a cable sling on the back of the machine. When the sling was full, the machine would travel to roadside and deposit the load on a waiting truck – a truly one man – one machine operation. The Beloit system, developed by Beloit Manufacturing, a builder of paper machines, was a three machine system consisting of the Beloit H-14 harvester, mounted on a tracked excavator chassis. A telescoping 52' mast equipped with a shear at the lower end and a carriage with a three knife chisel delimber and topping shear replaced the excavator bucket. The machine moved into position, and swung the boom to attach it to a standing tree. The delimber closed around the bole and was pulled upward on the mast, delimbing as it went. When the carriage reached a 4" minimum diameter or the end of the mast, the topping shear closed and topped the tree. The stem was then held by the delimbing head while the larger shear cut the tree at groundline. The tree was lifted and piled into a "bunch" consisting of all the trees the machine could reach from that position. The second machine in the system was a rubber tired skidder with the conventional winch and fairlead replaced by a boom and large grapple. The skidder would pick up the entire bunch left by the harvester and move it to roadside where the stems would be loaded tree length by a second excavator mounted grapple loader.

The invention of these machines was a major stepping stone that moved timber harvesting to a fully mechanized activity, reducing the amount of time a man spent with a chainsaw, and making felling much safer. Hydro-Ax originated in 1973 as a division of Blount Equipment with the production of a rubber tired tractor with a mowing attachment and soon entered the timber harvesting market by producing felling and bunching heads that employed a variety of shear and saw attachments. When Timberjack acquired Koehring Waterous, several engineers were put out of work and they approached MacDonald Steel about forming a forestry machine division. The result was the formation of Tigercat Industries in 1992. This company, much like Franklin, began listening to loggers' needs and concerns. Their research found that drive-to-tree feller bunchers were not meeting expectations so they produced the 720 and 726 which were soon recognized for their production capabilities in poor terrain. The problem, however, was the lack of a sufficient cutting head for the machines so the company began producing felling heads employing rotary saws and shears to be attached to their machines. Hydraulics drove the development of machines that not only removed the tree from its stump but removed limbs and bucked the logs. The development of the circular saw head by John Kurelek, one of the engineers responsible for the creation of Tigercat, eliminated shattering and introduced carbide tipped cutting teeth. It became the preferred cutting style in the mid 1980s when Georgia Pacific stopped accepting shear cut logs. Finally, loading and transport of tree length materials was the last step of logging to undergo mechanization. The loading technology for tree length systems is much like that employed in forwarders of cut-to-length systems but slightly larger to deal with heavier materials. The first loading systems designed used the technology that was available for cable skidding but surprisingly, many early loading techniques relied on the same physics that dictate modern day knuckleboom loaders and stemmed from earlier applications outside of the forest industry, mostly in mining. A technique called "heel booming" used a pair of tongs to grip a log off center and push the shorter end into the heel of the boom or rack that the lines hung on and the log was then swung over the rail car (Drushka and Konttinen, 1997).

As with skidders, many equipment producers attempted to design and build loading machines for both shortwood and tree length material. The development of the hydraulically controlled knuckleboom is regarded by most as the biggest revolution in loading technology and created the principle by which modern loaders were developed. The introduction of this machine in North America came with Bob Larson's alteration of a Swedish machine called the Hiab. He called his version the Hiabob which was built from two short booms joined together by hydraulics cylinders allowing the boom to pivot. The original machine had a pair of tongs at its working end but Larson placed a hydraulically operated grapple capable of quick and precise loading. It was also equipped to rotate through hydraulic power (Drushka and Konttinen, 1997). Larson later sold his company to Beloit but is still credited with introducing grapple loading into the United States. Leo Heikkinen is also credited by some as being the first producer of an American made loader. His version of the machine was a truck mounted combination of boom, cable and winch loading that he converted to operate hydraulically. Heikkinen's company later took on the well known Prentice label.

Prentice has stayed very active in loading technology as well as Barko, Tigercat, Timberjack and John Deere. The initial development of one machine for one task by one manufacturer no longer exists. All loader manufacturers offer a variety of machines that are truck mounted, trailer mounted or tracked and can handle all sizes and types of timber. Hydraulic controls are now standard on every loader produced and fuel use is more efficient to maximize output for the owner in addition to maintaining environmental standards.

In summary, the machines used in modern logging operations developed partly to replace men and draft animals. The trend toward mechanization began with the replacement of draft animals by the skidder and forwarder. They were based on the technology already available to agriculture and were further advanced by the knowledge gained in hydraulics and diesel power. Early skidders still required the use of manpower to attach cables but the introduction of the grapple eliminated this problem. Feller-bunchers were developed to maintain a constant operation for skidders. Originally they were only designed to cut and bunch stems but the development of the processor has turned some systems, mainly cut-to-length, into two machine systems. Processors are equipped with a felling head as well as equipment to delimb, top and buck trees. Finally, the knuckleboom loader was developed parallel to the feller-buncher to increase overall efficiency and production of mechanized systems. Early loaders consisted of only cable or ropes tied to a spar tree where manually operated tongs were strung. The hydraulically operated grapple, also seen in skidders, helped reduce the amount of time a person needed to operate the machine. Advantages from hydraulics in all machines increased safety of the operator as well as production of the system. Consequently, it was not the development of machines that caused labor to migrate, but the migration of labor caused the need for machines.

Manufacturing technology was evolving apace with machine technology. Tom Baker of St. Regis Paper Company built the first “chip mill” at Fargo, Ga. This essentially divorced the wood room, that sector of a pulp mill responsible for debarking, chipping and screening and moved it to locations remote from the pulpmill. Wood was brought to the chip mill in tree length form, transferred to an infeed conveyor, debarked by ring debarkers and chipped without being bucked to length. The chips were loaded directly to rail cars for transport to the pulp mill in Fernadina Beach, Fla.

Two other product innovations, chip and saw lumber production and southern pine plywood, appeared. Portable sawmills of the era sawed logs with the bark on. The slabs, the portion removed in squaring the log were a promising source of pulp furnish, but debarking slabs proved problematic. The chip and saw method of producing lumber where the log was "slabbed" or squared into a cant by chipping heads and then passed to resaws for reduction to dimension lumber and boards allowing high speed production of lumber from small diameter logs. This had the added advantage of capturing much of the mature wood in the periphery of the log that had the best fiber quality for paper manufacture in chip form while converting the juvenile wood core into lumber. The development of glues suitable for making plywood from southern pine species allowed the manufacture of structural plywood from fast grown pine species. Both processes required rather precise bucking; one to minimize waste in sawing, the other to assure the log would fit between lathe centers and avoid round-up waste. Bucking of this precision was best done by an operator looking at an entire stem from an elevated position and aided by electronic measuring tools, using fixed position saws to reduce the stem for processing, rather than by a semi-skilled woods worker with a measuring stick and a chain saw.

The question of which system, cut-to-length or tree-length, has not been resolved nor is it likely to be. The cut-to-length system serves well in those forest types with a deep canopy such as the spruce/fir forests of the north, were limbs occur along much of the length of the stem. Since the entire stem has to be delimbed, bucking it at the same time is rational. Cutting the stem to product lengths and carrying them out on a forwarder reduces the breakage associated with dragging sometimes frozen stems over rocks and rough terrain; the same terrain that makes road building expensive. The Scandinavian industry has developed sophisticated cut to length harvesters that include on-board computer controlled measuring and bucking capability, and forwarders for transport from stump to roadside.

Trees in the temperate forests of the Southern US tend to develop lighter crowns. A rule of thumb for loblolly pine (P. taeda) management is that stand density should be such that one third or less of total tree height is maintained in live crown. The portion of the merchantable stem requiring delimbing is considerably less. Gate delimbing as a part of the skidding cycle, backing an entire turn of stems through a metal grid to break off most of the limbs close to the stem developed in the 1970s. “Pull through” delimbers mounted on the loader carrier developed during the 1980s as a means of removing the stubs, and topping to a diameter limit. Both tools only dealt with the portions of the merchantable stem that contained a commercial product and required active delimbing.

The southern US has developed tree length systems replacing shears with high speed saw-head feller bunchers mounted on purpose built hydrostatic wheeled and tracked carriers, grapple skidders, knuckle boom loaders, and tree length trucking. Some tracts require that a portion of the wood harvested be bucked and segregated at the landing when different stem components move to different markets. Some operations use two knuckle boom loaders, one to process those stems and pile the product for the second loader which is responsible for loading trucks.

In-woods chipping of whole trees or logging residues has met with variable success as a means of simplifying wood supply. Morbark, a company that produced portable debarkers for portable sawmills was a pioneer in this area, building chippers for in-woods and rail yard applications. The first attempts were directed at taking both the debarker and chipper to the woods. Portable debarkers of the rosser head type were unable to match output with the throughput of portable chippers, reducing the economic advantage. Some mills were able to use "barky chips" produced by chipping stems with the bark on, and that approach was favored for a time, but complaints over the effect of minerals caught in the bark and the increased bleaching requirement limited the application.

From barky chips it was only a short jump to producing whole tree chips. Processing the entire above ground portion of the tree from butt to bud increased fiber recovery especially from hardwoods, improved the appearance of the cut over tract, and reduced the cost per ton produced. Again, some mills could accept a limited amount of whole tree chips in their furnish. Application was hindered by increased wear in chip handling systems, increased scale buildup in digester plumbing and other manufacturing problems. But whole tree chips proved valuable as fuel to offset the increased coal and oil prices of the late 1970s and more recently to allow the forest products industry to maintain production in economically unstable times.

To summarize, labor and machines evolved with and because of one another. Family labor in the settlement period devised simple machines and procedures to remove timber from future farmland as well as utilize its value for basic necessities and trade more efficiently. When labor evolved into a mixture of family and slaves, machines saw little advancement due to increased labor supply. The Civil War spurred mechanization by decreasing labor supply and abolishing slavery, transforming labor into a family/wage mixture that eventually led to sharecropping. The Depression years did little to advance machines but the forest industry was able to absorb displaced labor, reverting back to the "cottage" industry seen during the settlement period. Perhaps the most influential times were World War II and the years following. The onset of the war caused new manufacturing jobs in northern states, decreasing labor supply in the south. This caused increased need for mechanization which was met in post WWII when veterans returned with knowledge acquired during their military service. Some applications of wartime technology found wide acceptance and some were barely realized but all contributed to the innovative period that began in the 1950s, forming the machines that are present today.

2.7 Technical research and previous cost studies

Most research focused on labor deals with economic factors associated with population growth and not labor directly involved in forest harvesting. It is widely accepted that developing countries rely heavily on the exploitation of natural resources to drive their economies. Research has also shown that a GDP level of $1200+ shows a positive correlation to percentage of forest cover (Foster and Rosenzweig, 2003). Therefore, one could assume that a certain level of income within a country would allow for more jobs in the forest industry unless that country is not heavily reliant on their forests. Publications from the United States Department of Labor (2007) showed increased labor productivity in the wood products sector and paper products sector of 6.5% and 1.5% respectively between 2004 and 2005. Other than statistical analysis, the labor sector of forestry, as most rural industries, is largely a subject of sociological study (Earle and Hoffman, 1980).

Equipment and mechanization research is more common in the forestry research sector. However, most is approached from examining variables of harvested stands such as tree size and acreage of tract. One publication from Holtzscher and Lanford (1997) focused on three cut-to-length systems and the effect that tree diameter had on their cost and productivity. All stands were generated from PCWThin, representing diameters of 4 inches to 11 inches. The result was that increased mechanization in cut-to-length systems increases the unit cost of production but also has an added benefit. The system with the lowest unit cost required more labor which tends to involve more accidents and may be responsible for worker turnover. Although not consisted with the methods of the Logger Cost Study, this research is valuable in showing the direct relationship that mechanization has on not only labor requirements but also labor satisfaction and safety.

Another study from Virginia Tech (2004) approached machine efficiency based on stand characteristics. A general overview of this research found that 40% of all logging contractors have to deal with inefficiency from mismatching of harvesting system to a stand. Four harvesting systems were examined beginning with mechanized systems involving a large contribution from manual labor (manual felling and cable skidder) to highly mechanized cut-to-length systems (processor/forwarder combination).

Efficiency was centered on average tree size, stocking density and harvesting intensity. Although the study was inconclusive, it contributed to the knowledge researchers have available in identifying inefficiency.

The initial formation of the database and analysis from the Logger Cost Study was completed by Loving in 1991 which further research was established upon. He was responsible for grouping all costs associated with logging production into six categories that can be seen in the following pages. He found that three of these categories, two of which being labor and equipment, constituted 75% of all costs. Another cost that was not included in this percentage but is directly related to both labor and equipment inputs is insurance.

LeBel (1993) continued this research with 22 contractors located in the southeastern United States with a more technical approach. Two major conclusions that LeBel reached were that tract size directly influenced the productivity of a contractor because of the amount of moving the contractor did between individual tracts and that eliminating in-woods sorting may increase productivity as well.

In 1999, Altizer expanded the application of the study to include contractors in the Appalachian area where tree length systems are not always applied. Different species are also present in this environment; therefore, a better overall system comparison could be performed. The inclusion of these contractors not only gave an analysis of the logging contractor sector in another geographic location but also added a new dimension into the long term analysis of logging. Findings were that contractor size as well as tract size and markets were smaller. Mountainous topography of the region required a predominately manual harvesting system which increased insurance costs but also lowered equipment costs.

Stutzman (2002) continued the analysis with 28 contractors. It appears from his research that the logging industry took a significant blow because equipment was being used beyond depreciable life and new equipment purchases decreased. Labor also felt the impact because workers not considered crucial to overall operations were removed and salaried employees were converted to hourly wages. During this part of the study, weather played a significant role in poor productivity and increased unit costs.

Jackson (2003) expanded the study to 40 contractors in 4 geographical regions: Coastal plain, Appalachian, Piedmont and Lake States. His research was focused more on the economic activities that affected logging contractors such as market shifts, mergers and price controlling factors. He concluded that the unrest seen in 1999 and 2000 was largely due to these economic factors but contractors began to adjust and adapt to the changing system by 2001. Overall, the area experiencing the largest increase in cost per ton was the Appalachian region from $18 in 1999 to $35 in 2001. All other areas were comparatively stable.

2.8 Factors of variability

An area to build upon from Jackson's research was the definition of variability. He defined five types of factors that are "enemies of efficiency". Three of those have a direct influence on labor and equipment: 1) natural 2) technical 3) regulatory.

Natural factors such as weather, soil, transportation routes and equipment malfunctions are a part of logging. Wet weather is most often the natural factor dealt with and the wood supply system has reacted in two ways to deal with production variability. The first is by stocking timber at a production facility. In the southeast, most of these inventories are kept under wet storage during summer months and drawn from to feed the mill during winter since wet weather is most prominent during this time of the year. The other adaptation to wet weather is instituted by the contractor. By using wider tires or dual tires on feller-bunchers and skidders, the weight of the machine is distributed across a larger area and less soil disturbance occurs.

Other natural factors such as entrance and exit routes to tracts may have a bearing on the contractor's production as well as bridge weight limits. The shortest route into a tract of timber may sometimes be primary and secondary unpaved roads that can not tolerate the weight of heavy forestry equipment even when it is being hauled. Therefore, a longer route into the tract may be required which takes more time and, depending on additional time added, could significantly alter unit production.

Technical factors of variation were the focus of most early studies and are the factors that affect both man and machine. A machine that is not efficient and a laborer unfamiliar with an assigned task are sometimes the most detrimental factor within a logging firm. Tract characteristics such as low density of large species variation can also compound these problems. Even with the progression toward intensively managed pine plantations, there are a significant amount of stands that are still of mixed species. A machine that does not perform relatively quickly in a thinning operation can be a contributor to increased cost per ton. Matching the right machine to a job and the right laborer to the machine will reduce the cost per unit of production the contractor sees.

Finally, regulatory factors are a third contributor to production variation. Contractors are expected to meet certain requirements and standards when performing harvesting activities. Proper education in Best Management Practices (BMPs) and Sustainable Forestry Initiative Certification (SFI) is required by many processing firms, thus increasing the cost a contractor absorbs to continue operation. Soil compaction regulations and emission guidelines set forth by the Environmental Protection Agency (EPA) influence the types of machines a contractor can operate which may require increased investment in equipment and parts.

This thesis, as stated previously will focus on labor and equipment as well as the additional costs of owning and operating these inputs such as insurance and consumable supplies.

CHAPTER III

METHODS AND PROCEDURES

The logger cost and productivity study was an ongoing research project begun at Virginia Tech in 1988. The project was moved to Mississippi State in 1997 and continued to be a tool used to evaluate the overall health of the logging force in the Eastern United States before concluding in 2011. Information on cost and production were gathered for each year and analyzed based on firm size and geographic location.

3.1 Contractor Participation

Contractors involved in this study have been recommended by state loggers associations, mill representatives or other professionals within the industry because of their respected reputation as harvesting contractors and compliance with state and federal laws and practices. Data is submitted either quarterly or annually. For the time period of this thesis, the population consisted of 48 contractors across 13 states and four geographic regions.

Upon recommendation, a meeting is arranged with the contractor to inform them of the purpose of this research and what will be provided to them. This is also the time when most demographic information is obtained and a date is set for additional meetings to update demographics and receive cost and production information. Cost information comes in the form of balance sheets and income statements provided by either the contractor's accountant or other individual in charge of record keeping. Production information is sometimes provided along with cost figures but is generally obtained from the contractor. Each participant is contacted by phone or email at least quarterly and researchers attempt to visit each contractor on site once a year. For contractors in the far north locations, on site visits may be possible only once every other year. Each contractor's information is kept confidential by issuing a specific identification number that is used when delivering reports to the entire population.

3.2 Methods

There were virtually two sets of data. The first, analyzed in Chapter IV was the complete data set that included every contractor that submitted at least one year of data. A summation of the overall cost and production for the period was derived first. Next the data was separated by geographic region. Within each year a count of the firms within each region, their median production and range of production were shown as well as a yearly average cost of each of the six cost categories (shown in Fig. 3.1) and their yearly percentages of total cost. The analysis of the Coastal Plains region was further separated into Gulf and Atlantic regions because, as the analysis progressed, it became apparent that trends differed on a sub-regional basis. Firms in the Piedmont region were grouped together without sub-regional splits. Only one firm from both the Appalachian and Lake States regions was present so the actual cost and production of these two firms (rather than medians) was presented.

Chapter V shows the analysis conducted on the data from 30 contractors that provided data for all four years. Quartile analysis was used first on the production of the population each year and the changes, based on percentage, from year to year as well as over the period were derived. Quartile analysis was then used to analyze total cost as well as the individual categories and comparisons were made year to year highlighting shifts within firms and groups. Finally, related costs such as equipment and consumables as well as the relationship between total cost and production were regressed to identify the extent of the relationships. The slope of each regression is a measure of the cost necessary to add one unit of production (the variable cost).The intercept can be considered as the costs of being in business; costs that exist whether the firm is productive or not. It can also be interpreted as a measure of continuing costs such as interest on equipment loans, depreciation, insurance (exclusive of workers comp) and administrative overheads that are independent of production. The R-squared value is a measure of variation in total cost explained by the regression.

Chapter VI is a discussion of the practical application of this project. Analytical tools used here were applied to industrial applications where similar firms that did not participate in this project were compared. In 2008, this data was used to assist a firm operating in Mississippi and Alabama "size up" their operation. Through comparison, this firm identified areas where costs were significantly higher and reformatted its strategy to be more cost efficient. Also, the mill that provided the majority of work to the firm was able to understand the impact moving had on the contractor and were more conscious of the tracts they purchased and asked this contractor to harvest.

In 2010, the data was used as a tool to assist a large Mississippi firm visualize their costs better. The owner was aware of the impact moving and weather delays had on his company but gained additional knowledge by learning how to produce this graphically.

COMPONENTS OF LOGGING COSTS

1. Equipment
A. Note payments (this shows actual cash flow to principal)
B. Depreciation (this will give us a good indication of equity)
C. Taxes (Highway use, property tax)

2. Labor
A. Payroll (wages and salaries)
B. Payroll taxes (FUTA, FICA, and Medicare)
C. Workers Compensation Insurance (please provide rate and experience modification factor if available)
D. Employee Benefits

3. Consumables
A. Tires
B. Fuel
C. Oil and Lubricants
D. Parts and Maintenance
E. Truck and Equipment washing
F. Non-depreciable tools (chains saws)
G. Gravel
H. Mats
I. Wrecker Service

4. Administrative Overhead
A. Secretary Wages
B. Bookkeeping or Accounting fees
C. Office expenses
D. Licenses
E. Fines
F. Legal and Professional Dues
G. Travel Expenses
H. Phone and CB Radio Expenses
I. Medical Expenses
J. Educational Costs

5. Insurance
A. General Liability
B. Equipment (Fire/Theft/Vandalism)
C. Umbrella Policy

6. Contract Services
A. Contract Hauling
B. Cut & Skid, Moving Expenses, other
C. Road Building/BMP

Figure 3.1 Cost categories.

With the exception of labor costs, most other costs are variable. Although equipment payments are fixed during the life of the note, the cost of owning that equipment shifts to a variable cost because of maintenance and likely increases in consumables costs once the note is paid and the depreciable life ends. Some equipment – such as chainsaws and other hand tools – are variable costs because of their relatively short useful life and relatively low replacement cost. This cost, however, is not always the same. Finally, one may assume that taxes would be an administrative overhead cost but highway use and property taxes would not be a factor without equipment or property to store/repair that equipment.

CHAPTER IV

COMPREHENSIVE ANALYSIS 2003-2006

Data was submitted by 48 contractors from 13 states. The majority continued to supply data across years, but the population changed slightly each year. This analysis shows the trends based on the geographic region in which the firms were located. The majority of the population was located in either the Coastal Plain (Gulf & Atlantic) or Piedmont region of the eastern U.S. The Appalachian and Lake States regions were represented by two firms, one in each region.

4.1 Coastal Plain Region

Firms in the Coastal Plain region are generally adapted to high volume production rather than production of high value because the timber is largely from naturally reseeded or planted pine stands on the easily traversed flat or gently rolling topography of the region. Stems, delivered to the landing, may be separated by broad species groups (pine vs. hardwoods) then by size classes (pulpwood, chip and saw, or saw timber) with grade separation done at the mill. Over the period, firms in the Coastal Plain were most numerous. The range in annual production for these firms varied by as much as 406,344 tons (2006). Median production was lowest in 2004 but had increased by 44.4% by 2006. From 2003 to 2006, these firms produced 14,858,956 tons which was slightly more than

80% of total production over the entire period. The median production along with the range for each year can be seen below in Table 4.1.

Table 4.1 Number of Coastal Plains firms and range in production by year

Year	# of firms	Median Production (tons)	Production Range from Min. to Max. tonnage
2003	29	98,751	330,015
2004	29	97,653	298,093
2005	29	126,538	357,251
2006	20	141,015	406,344

As production for the group increased, so did total cost. In 2003, the median total cost for a Coastal Plain firm was $1,966,986. By 2006, the cost had increased by almost 40% totaling $2,751,336. Cost per ton, however, only increased by 22% and was highest in 2006 at $18.05/ton. This observation shows how firms in this region used increased production as a method for offsetting rising costs.

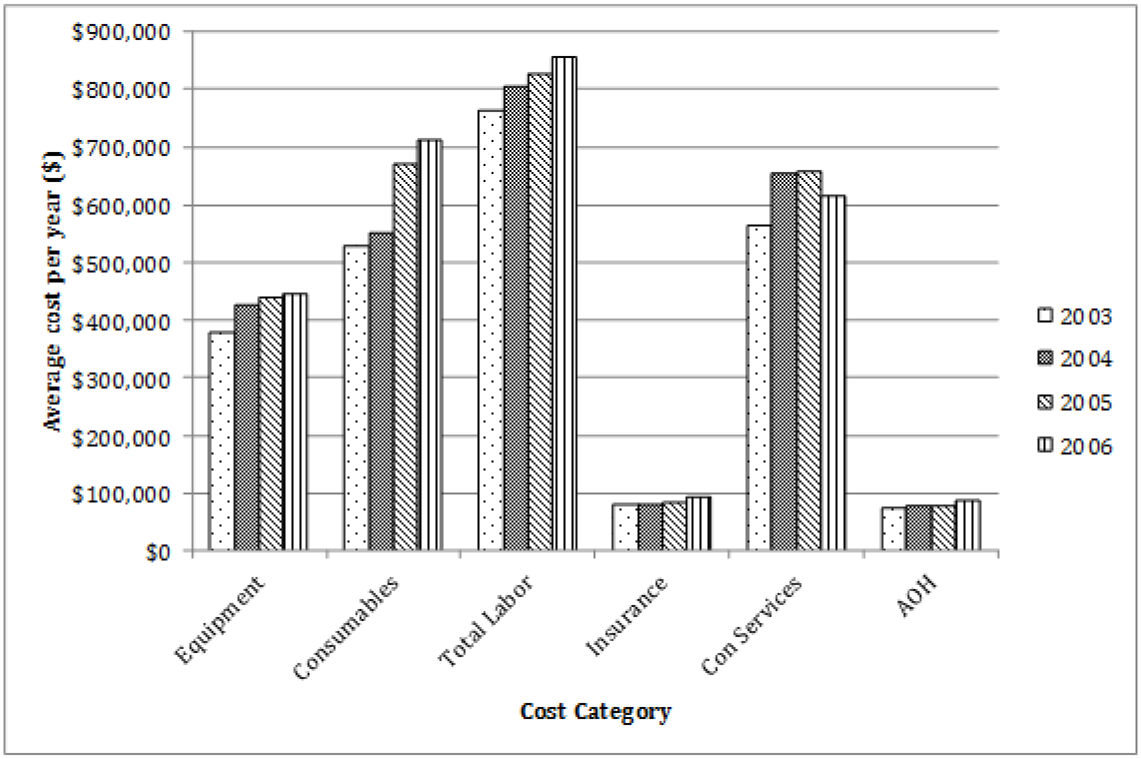

Figure 4.1 Average cost per year by category for Coastal Plains firms in total dollars from 2003 to 2006.

Labor cost was consistently the most expensive input for these firms in terms of total dollars. In 2006, labor cost had increased 30% from 2003 averaging $837,851. Contracted Services were the second highest cost in 2003 and 2004. Consumables cost rose by almost 68%, due largely to the increase in the cost of petroleum products, to become the second most expensive category in 2005 and 2006.

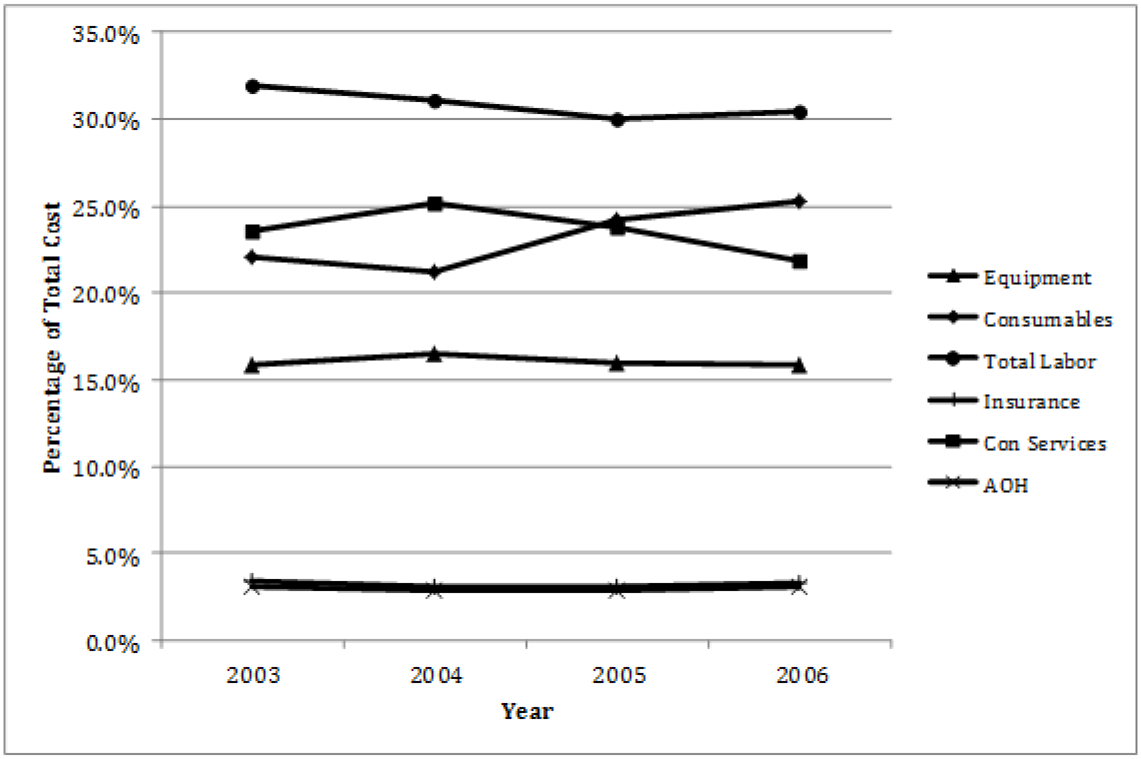

Figure 4.2 Percentage of total cost by cost category for Coastal Plain firms from 2003 to 2006

Although Labor increased in total dollars spent, it decreased as a percentage of total cost by 2.3%. Firms spent increasing amounts in each category as the period progressed but the dramatic increase in Consumables cost explains the changes seen in Figure 4.2. Firms were forced to reallocate capital to deal with rising Consumables cost.

On a sub-regional basis, the population was split as evenly as possible by state. Five states were in the Gulf Coastal Plain and four were in the Atlantic Coastal Plain. Median production in the Atlantic region was consistently higher than in the Gulf region, almost 76,000 tons for the entire period. Median cash outlays for the Atlantic region were also higher at $2,357,094 compared to $1,328,170 for the Gulf region. Given these figures, cost per ton was about $0.80 higher in the Gulf region over the period.

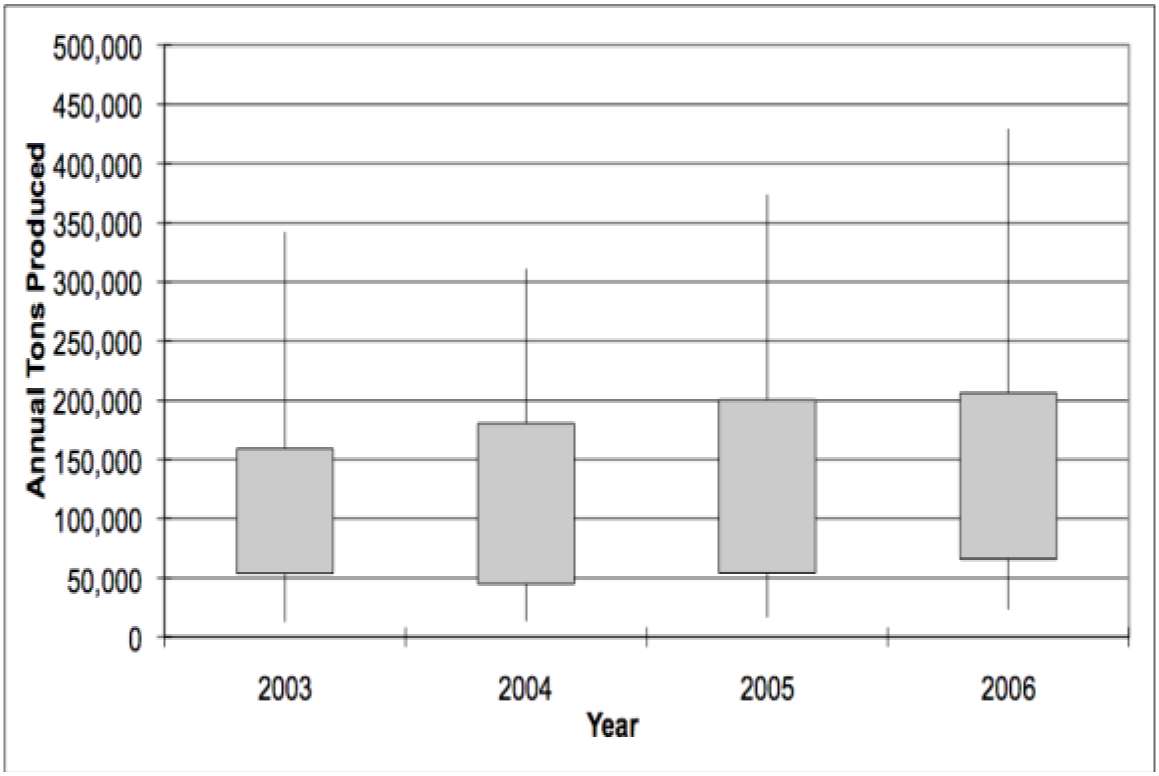

Figure 4.3 IQR and total range of production for Gulf Coastal Plain firms by year.

The IQR increased slightly over the period. Minimum production was relatively unchanged while maximum production increased dramatically due to the increased production of one firm which is discussed further in Chapter 5.

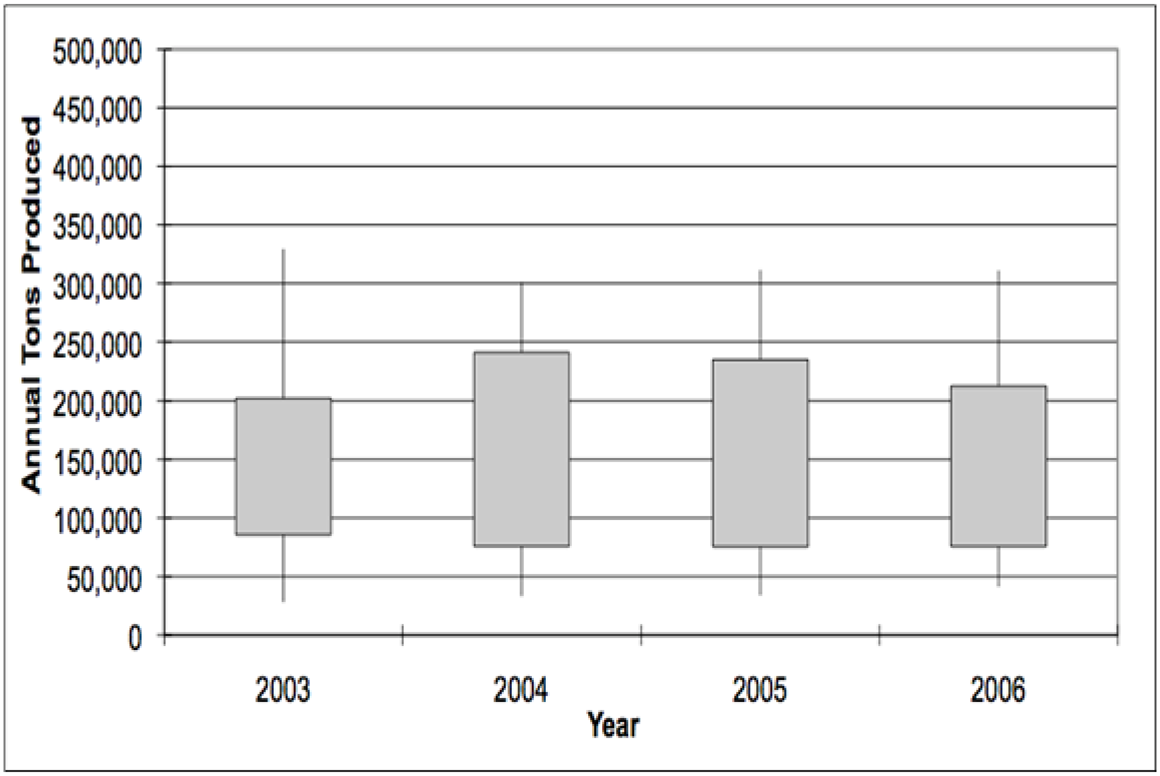

Figure 4.4 IQR and total range of production for Atlantic Coastal Plains firms by year.

Atlantic firms did not vary like their Gulf counterparts. Year 2004 is particularly interesting for this sub-region because the largest IQR (165,307 tons) was part of the smallest total range (268,078 tons) for the entire period. To summarize, median production shifted upward as well as maximum production for the Gulf region. The Atlantic region, however, stayed fairly constant throughout the period with little increase in minimum and maximum production and a decreasing IQR after 2004.

4.2 Piedmont Region

The physiography of this region is generally hillier with sometimes drastic changes in elevation. Average production and average total expenditures lower than their Coastal Plains counterparts but cost per ton is usually higher. Over the period, these firms produced 2,939,822 tons which was roughly 16% of the total production. Average cost in this region was $1,382,054 and a firm could expect to pay an average of $20.69 per ton.

Table 4.2 Number of Piedmont firms and range in production by year

Year	# of firms	Median Production (tons)	Production Range from Min. to Max. tonnage
2003	11	48,566	211,869
2004	12	50,213	245,603
2005	12	43,620	136,571
2006	11	47,477	103,395

The highest production for the group was in 2004 when one firm increased its production by approximately 15% from 2003 before dropping by more than 40% in 2005. The production of the remaining firms was fairly constant throughout the period so the volatility of one firm explains the statistic seen above.

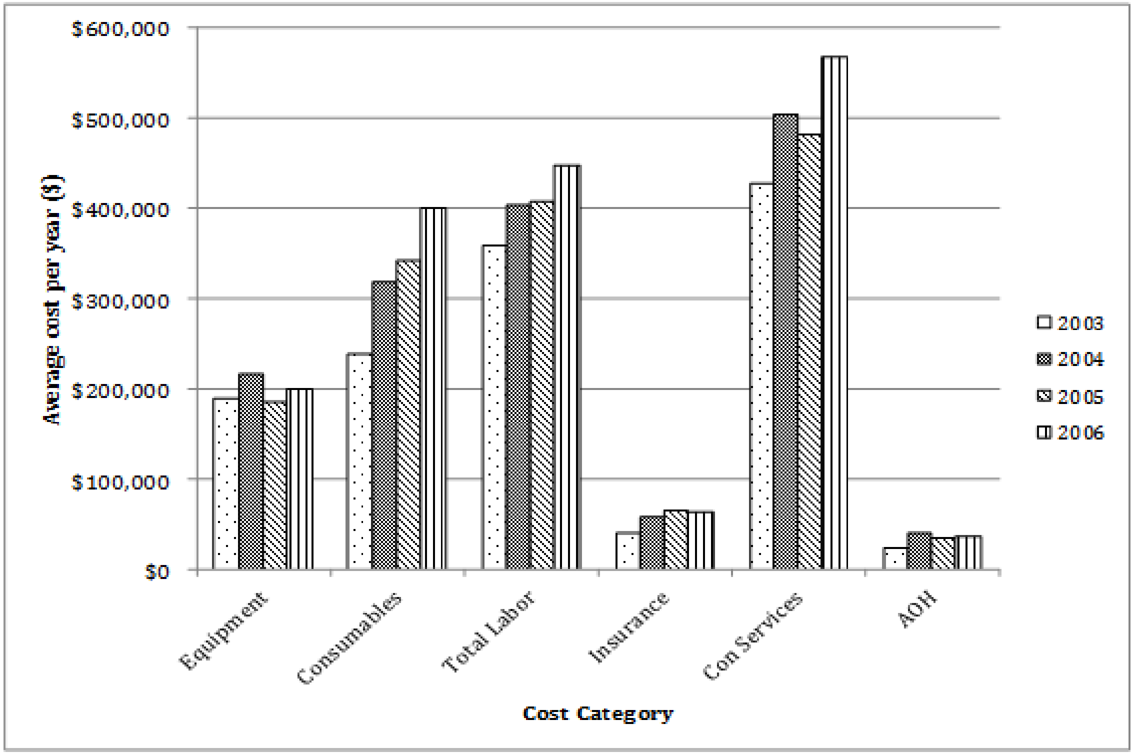

Figure 4.5 Average cost of six categories for Piedmont contractors by year from 2003 to 2006

These firms spent most for Contracted Services in all years, but the actual amounts fluctuated year to year. Over the period, Contract Services cost had a net increase of 32%. Labor, the second highest cost increased 23% over the period and ended accounting for 27.3% of total cost. Finally, Consumables were a close third increasing by 63% but only making up approximately 22% of total cost in 2006.

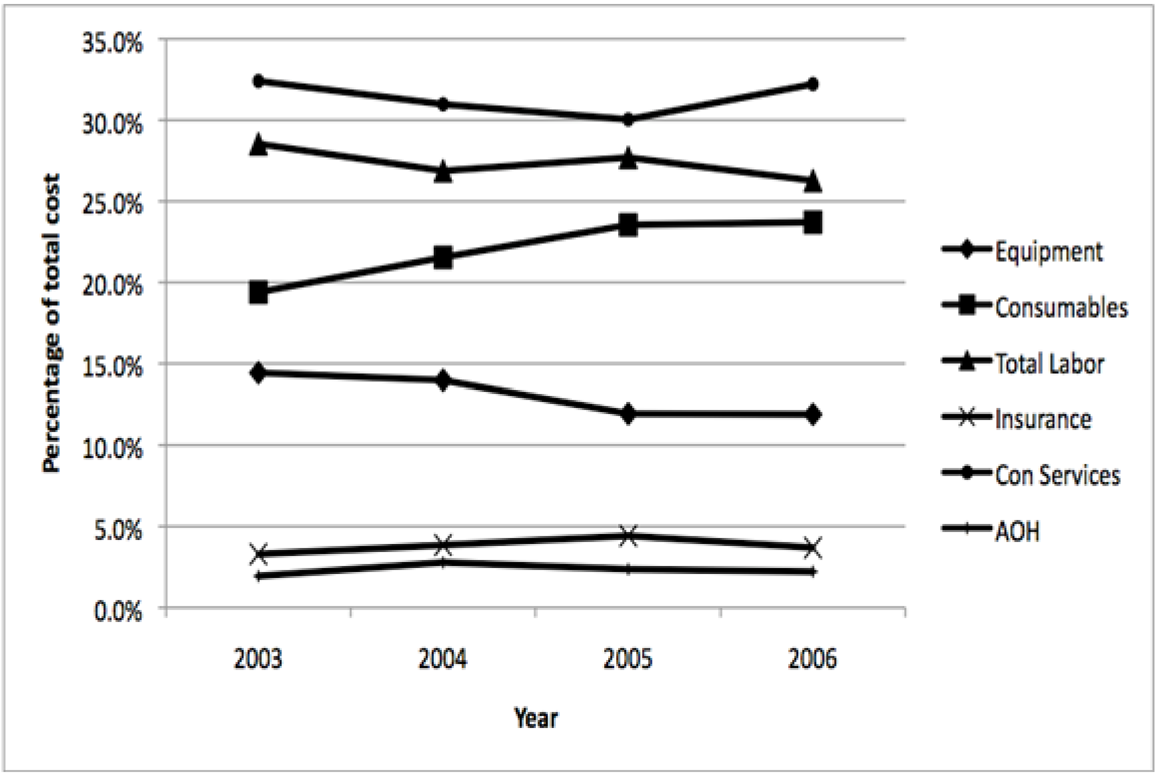

Figure 4.6 Percentage of total cost by cost category for Piedmont firms from 2003 to 2006

The cost structure for Piedmont firms mirrored those of the Coastal Plain firms. Contract services, labor, and consumable supplies accounted for roughly 80% of the total. Lower production compared to Coastal Plains firms might explain, to some extent, why Piedmont firms had higher percentages of their total costs in Contracted Services. Since production may be as low as four loads per day, some contractors choose not to invest in their own trucks and instead paid someone else to haul their products. There is also a probability that trucking distances may be longer for piedmont firms and contractors choose to transfer cost of hauling to independent firms that specialize in hauling timber.

This could also explain why equipment cost, as a percentage of total cost, is less than that of Coastal Plains firms. But again other reasons may prevail. The soils of the piedmont tend to have better trafficability when wet, obviating the need for newer and more expensive, high flotation, equipment.

Although it appears that insurance increased during the period as well, keep in mind that Figure 4.6 shows percentage of total cost. The largest increase in insurance actually was between 2003 and 2004, but overall insurance never accounted for more than 4.4% of total cost.

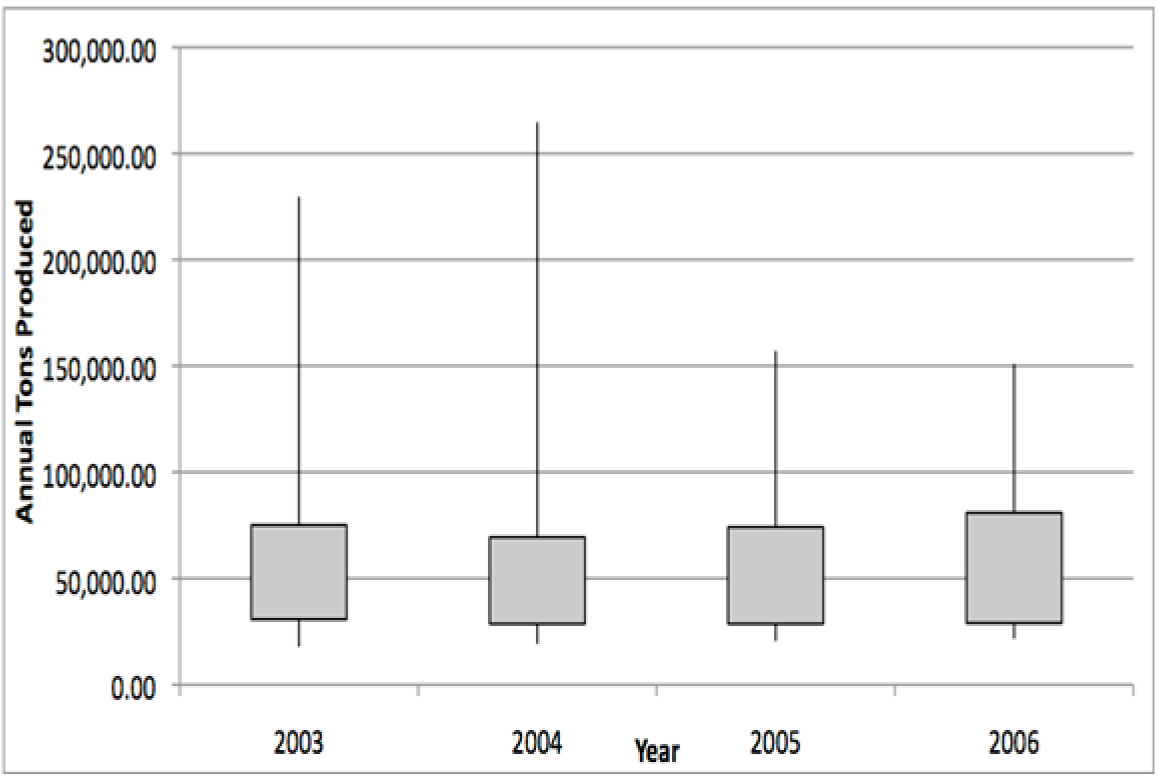

Figure 4.7 IQR and total range of production for Piedmont firms from year to year.

The figure above explains why it is more important to focus on the median production of these groups rather than the mean. The largest range in production was obviously in 2004 with 245,603 ton span between smallest and largest producer.

Computing an average for this group would have given great statistical measurements about the population but would have done little to explain what happened within the population. Median production in the Piedmont region stayed relatively constant varying by only 6,500 tons at most between 2004 and 2005.

4.3 Appalachian & Lake States Regions

These regions, although very different, are more difficult to log than Coastal or Piedmont regions. The Appalachian region has steep topography requiring tracked equipment that has more ground contact and cable skidding to move logs up hillsides. Production of Appalachian firms is significantly lower than all other regions and they focus production on quality rather than quantity. Firms in the Lake States employ different equipment strategies that are geared to the processing of stems with limbs from the stump to top. Also, the overall system is different in that some firms contract only the cutting and skidding of timber and others contract the loading and transport. With much colder environments than their southern counterparts, Lake States firms have the convenience of frozen ground in winter. Unlike the Coastal Plain and Piedmont region, where some soils become saturated and boggy during winter precipitation, Lake States firms lose little production due to rutting and spinning, except during “break-up”.

Only one firm represented the Appalachian region over the period. Production varied by 12,500 tons and total cost by $86,331. This firm averaged 30,775 tons and produced a total of 123,100 tons from 2003 to 2006. Cost per ton fluctuated by $12.25 over the period with the highest cost per ton in 2004 of $40.56. Production was lowest for that year and total cost was the second highest of the period. Consumables accounted for

26.3% of total outlays and Equipment and Labor were second at 24.4% and 23.8% respectively.

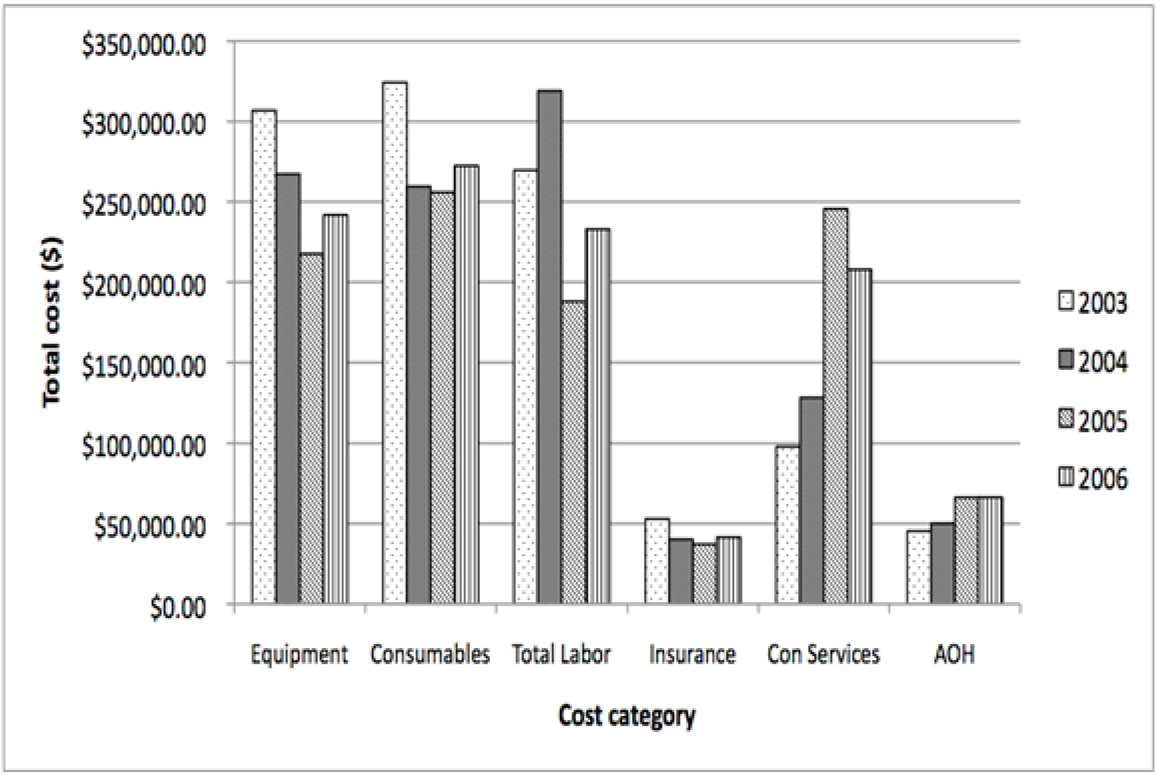

Figure 4.8 Cost categories for an Appalachian firm from 2003 to 2006.

There was also only one firm representing the Lake States region. This firm increased production by 412% over a four year period with total cost increasing by almost 513%. Contracted Services was consistently the highest cost each year and increased 940% over the period. Equipment was the second highest cost and increased by 366%. Although the increase in production and individual cost centers is staggering, perhaps the most useful observation was the change in cost per ton. In 2003, this firm had a cost of $19.95 per ton, $25.88 in 2004, and $28.49 in 2005. In 2006, labor decreased by almost 40% and AOH decreased by 65%. This ultimately lowered cost per ton by $3.66 and production rose 23,435 tons (32%). This firm is an ideal illustration of how firms can increase production while reallocating costs in a way that makes the business more economically viable and lowers marginal cost of production.

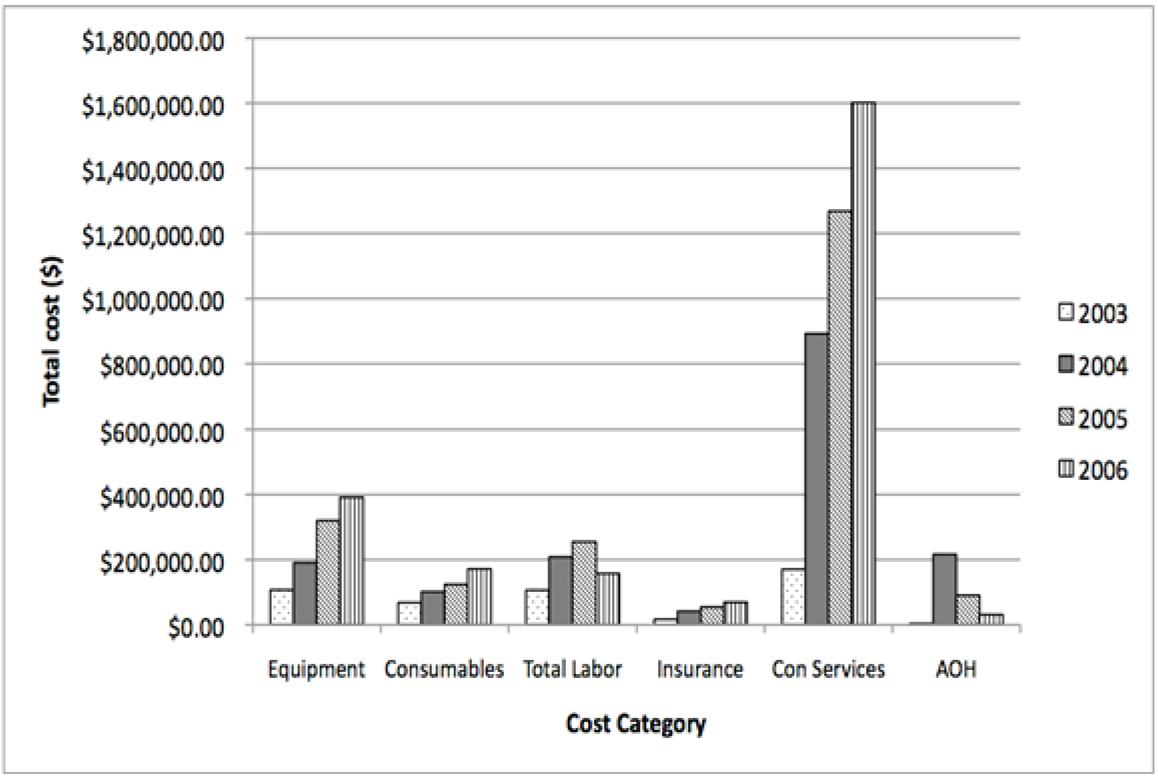

Figure 4.9 Cost categories for a Lake States firm from 2003 to 2006.

CHAPTER V

LONG TERM ANALYSIS

5.1 1 Production

The performance of a suite of contractors can best be shown by assessing the productivity of the whole over time. Annual production data for 30 contractors were summarized in distributions.

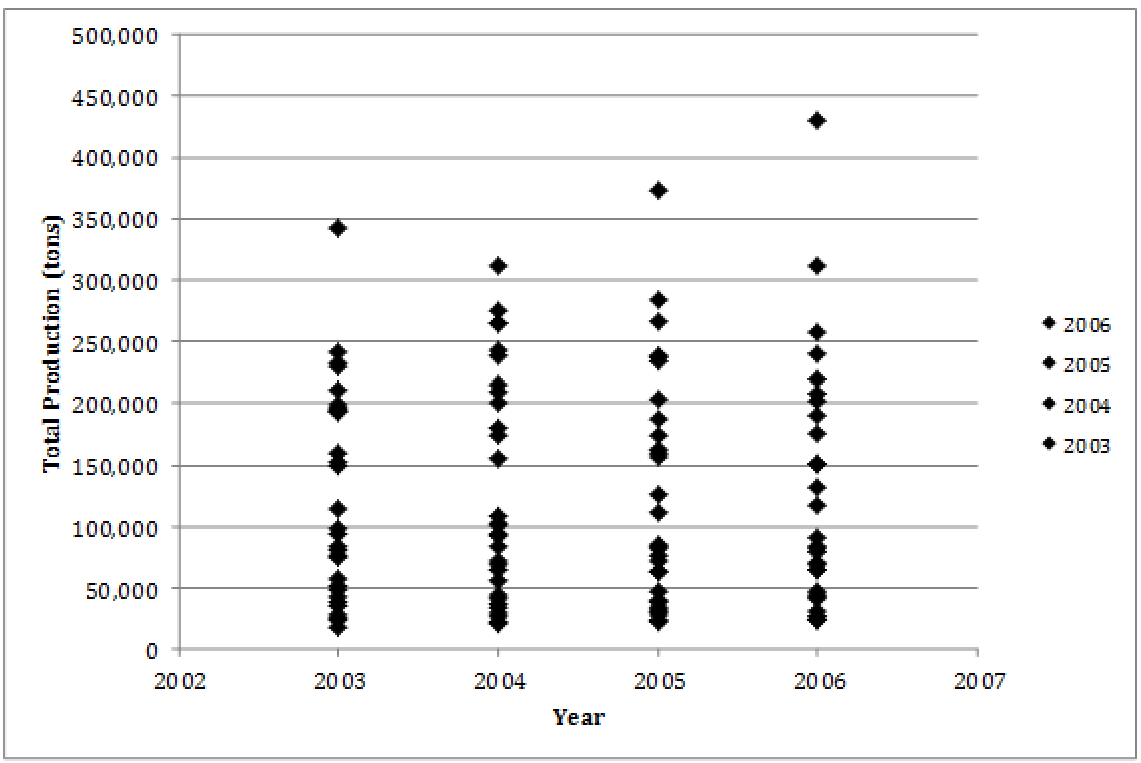

Figure 5.1 Production distributions for 30 firms from 2003 to 2006

Size alone is not an indicator of success for logging firms. Well managed firms of different sizes can succeed by developing a robust business plan adapted to different markets and geographic regions. This holds true when the data from many different firms or the same firm from year to year, the business plan must be flexible enough to adapt to the changes in weather, markets, regulations and other forces affecting operations.

Grouping the population in quartiles provides better understanding of the overall shifts in production (or opportunity to produce) from year to year. It is interesting that the production of both the smallest and largest firms and the overall range increased over the period while the range between the two middle quartiles contracted slightly.

Table 5.1 Production quartiles and quartile changes in tons for 30 firms from 2003 to 2006.

Quartile	2003	2004	2005	2006
Minimum	17,813	21,332	22,379	22,959
25%	49,331	47,335	41,889	45,120
Median	96,430	97,653	84,402	82,798
75%	194,019	207,365	184,028	187,175
Maximum	342,508	311,388	373,761	429,440
Range	324,696	290,056	351,381	406,482
		Change		
	2003 -2004	2004-2005	2005-2006	Total
Minimum	20%	5%	3%	28%
25%	-4%	-12%	8%	-9%
Median	1%	-14%	-2%	-15%
75%	7%	-11%	2%	-3%
Maximum	-10%	20%	15%	25%
Range	-11%	21%	16%	26%

The spread between the largest contractor in the first quartile and the smallest contractor in the fourth quartile (the inter-quartile range or IQR) for the population is particularly interesting. From 2003 to 2004, it increased by roughly 4% as both groups of contractors increased production. That increase disappeared by 2005, falling approximately 12%. Over the entire period, the IQR decreased by 7% (less than the average small firm production) meaning that, over the period, total production for the population increased, largely as a result of the growth of the largest contractor.

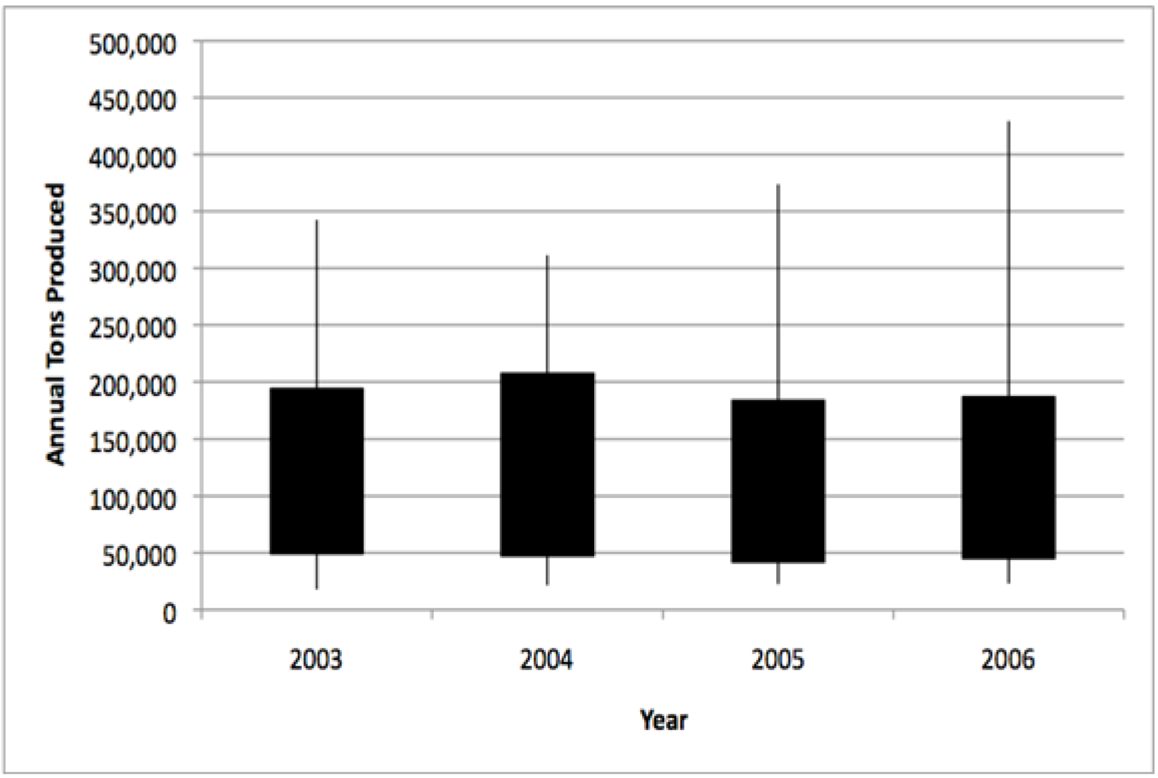

Figure 5.2 Production quartiles for 30 firms from 2003 to 2006.

The population was dynamic, operations adding or losing production year-to-year as a result of market conditions or business decisions. The lower outer bound, minimum production, increased and was represented by three different firms over the course of the study. The upper outer bound, maximum production, increased overall as the result of growth by two contractors. Growth was largest in 2005 and 2006, ranging from 186,485 to 238,665 tons. The cause of this increased variation came from two different sources. One contractor increased overall production 118% for the period while other large contractors remained stable or decreased. The second was a "shrinking" of the second quartile. The median production (the upper bound of the second quartile) dropped nearly 14,000 tons over the four years, while the spread of production within the third quartile only increased by 9,800 tons. Quartile analysis reveals that the population as a whole had relatively stable production but shifts of position within the population were dramatic. Some firms went through major changes in production, shifting between quartiles.

The shift in the population explains some of the change. The production required to be considered a large firm had to exceed 149,500 tons in 2003, 154,900 tons in 2004 and 157,075 in 2005. In 2006, however, threshold dropped to 116,532 tons. The medium firm threshold production followed a different trend. In 2003, breakpoint was 74,360 tons and decreased in 2005 to 62,430, and rebounded by 2,500 tons, ending with an overall decrease of roughly 13%. Separating the group by major breaks in production also reinforces what quartile analysis revealed. Figure 5.3 shows the range of small, medium and large firms and how they changed year to year.

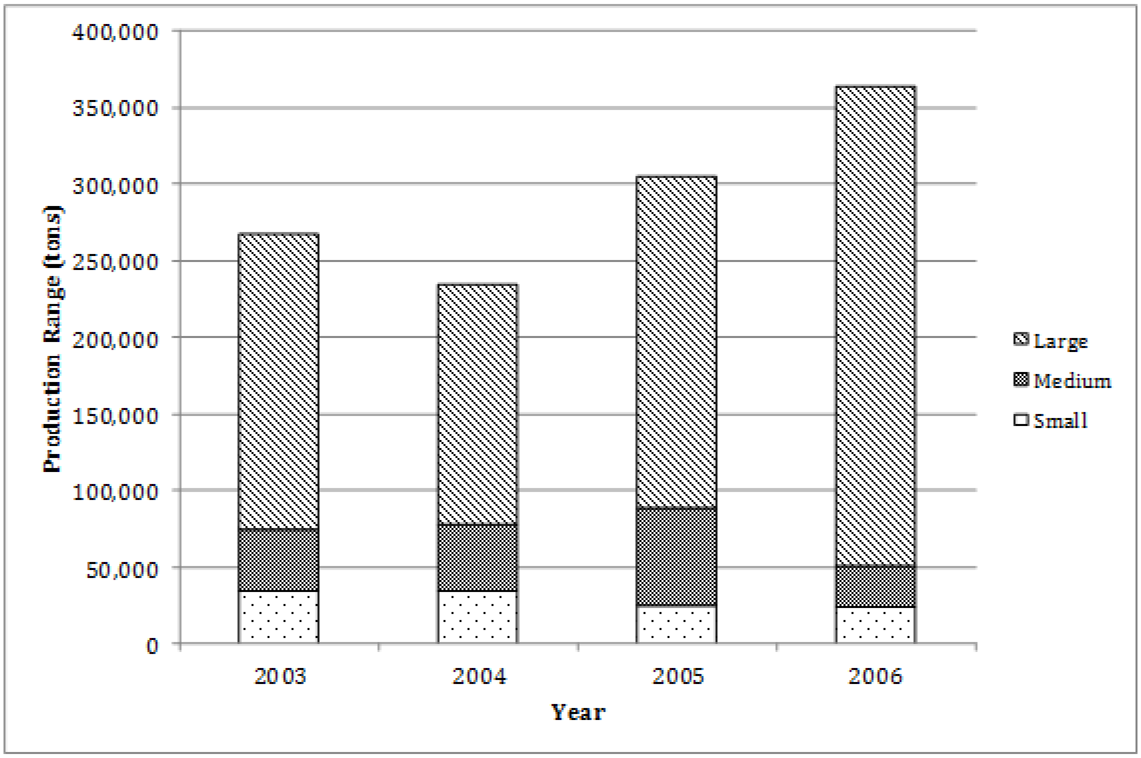

Figure 5.3 Production ranges for small, medium and large firms from 2003 to 2006

By 2006, it appeared that medium firms were moving in one of two directions. Decreasing production and moving into the small firm territory, hopefully reducing costs faster than decreases in production. The other outcome, becoming a larger firm, meant increased capital cost in additional equipment, labor and overhead. Those shown in Table 5.2 moved, at least once, between sub-groups, the small firms have a white background, the medium sized a light grey and the large firms a dark grey.

Table 5.2 Contractors moving between size sub-group over the period.

ID	2003 tonnage	2004 tonnage	2005 tonnage	2006 tonnage
105	48,566.36	55,970.47	62,966.78	83,098.93
212	94,108.82	100,897.45	126,538.09	131,125.05
351	57,790.47	72,171.37	82,176.38	78,656.54
417	159,352.36	174,067.50	174,286.74	64,919.71
777	114,189.00	102,956.00	111,696.00	116,532.00
806	149,525.54	108,959.80	83,265.15	91,360.07
810	75,861.00	68,501.84	47,081.95	47,477.29

On an individual level, firm 777 was the largest medium sized firm in 2003 and the smallest large sized firm in 2006. Firm 806 was the smallest large firm in 2003 and the largest medium firm in 2006. Over the period both firms' production varied and both were always near the threshold. This "border riding" effect applied to all firms except 105 and 417 who moved between sub-groups because of drastic production changes. These seven firms will be used later to demonstrate the costs associated with production shifts.

5.2 Total Cost

Changes in total costs, the six component cost groupings, and the cost per ton across the four year period were explored. Rates paid for logging services tend to move slowly with changes in the larger economy while costs remain dynamic. Contractors reallocate expenditures across groups to cope with cost pressures and constraints on productivity as well as slow changes in rates. They may also choose to contract more or less of their operation to outside firms as business and market conditions change.

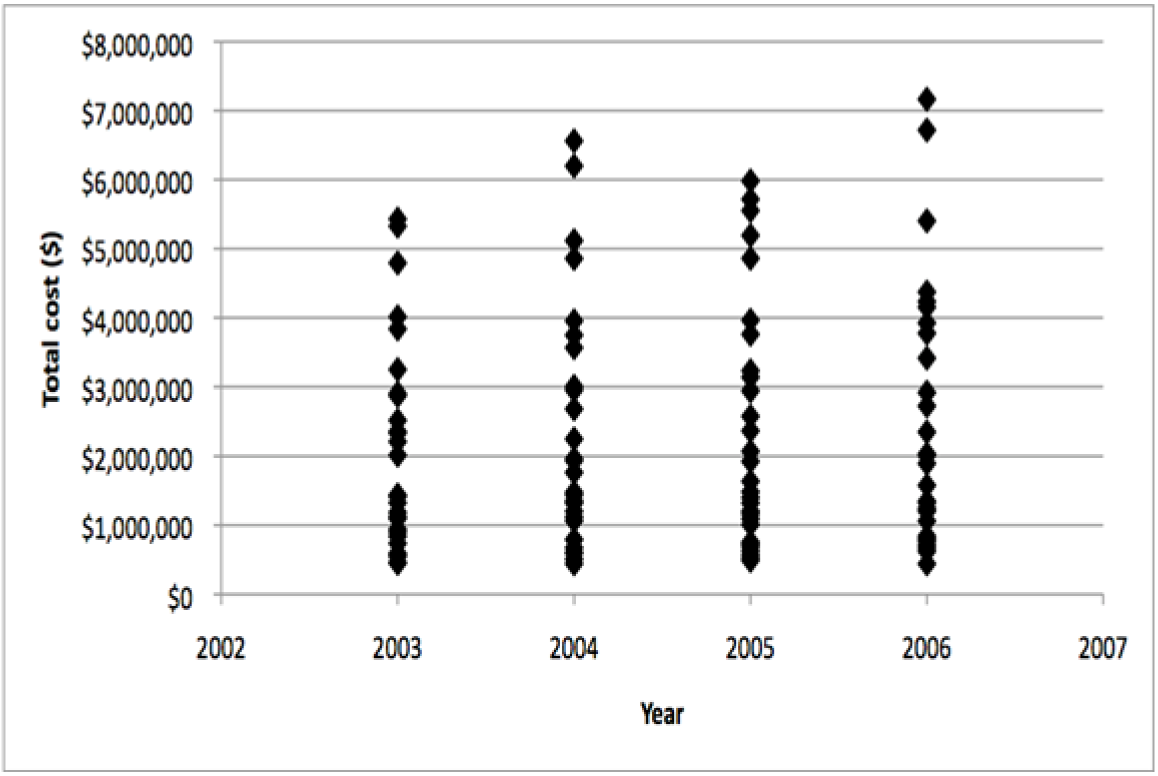

Figure 5.4 Total cost distribution of 30 firms from 2003 to 2006.

As would be expected, changes in the distribution of total costs mirrored the annual change in production. Average total cost per year varied between $1.9 million and $2.4 million while the median range of total cost varied by $1.4 to $1.8 million. The table below shows the variation in total cost more specifically by quartiles. Note that quartiles almost double in all cases.

Table 5.3 Quartile analysis of total cost for 30 contractors from 2003 to 2006

	2003	2004	2005	2006
Minimum	$448,161.10	$442,198.33	$489,716.10	$441,234.97
25%	$855,115.69	$860,911.41	$819,906.25	$898,322.34
Median	$1,422,456.88	$1,458,994.45	$1,559,740.80	$1,895,390.34
75%	$2,787,737.72	$2,992,266.60	$3,207,914.99	$3,685,442.82
Maximum	$5,429,060.81	$6,561,711.01	$5,982,212.67	$7,165,366.54
Range	$4,980,899.71	$6,119,512.68	$5,492,496.57	$6,724,131.57
		% Change		
	2003 -2004	**2004-2005**	**2005-2006**	**Total**
Minimum	-1%	11%	-10%	0%
25%	1%	-5%	10%	6%
Median	3%	7%	22%	32%
75%	7%	7%	15%	29%
Maximum	21%	-9%	20%	32%
Range	23%	-10%	22%	35%

Minimum values stayed relatively constant over the period although there were changes in the firms occupying that position year to year. Between 2004 and 2005 minimum total cost increased 11% but that was offset by a 1% decrease between 2003 and 2004 and a 10% decrease from 2005 to 2006. Over the period, minimum values were represented by two different firms. The 25th percentile decreased between 2004 to 2005 but increased between 2003-2004 and 2005-2006 leading to a 6% overall increase. The 75th percentile increased each year ending 29% higher than it started causing the IQR to increase in range as shown in Figure 5.5.

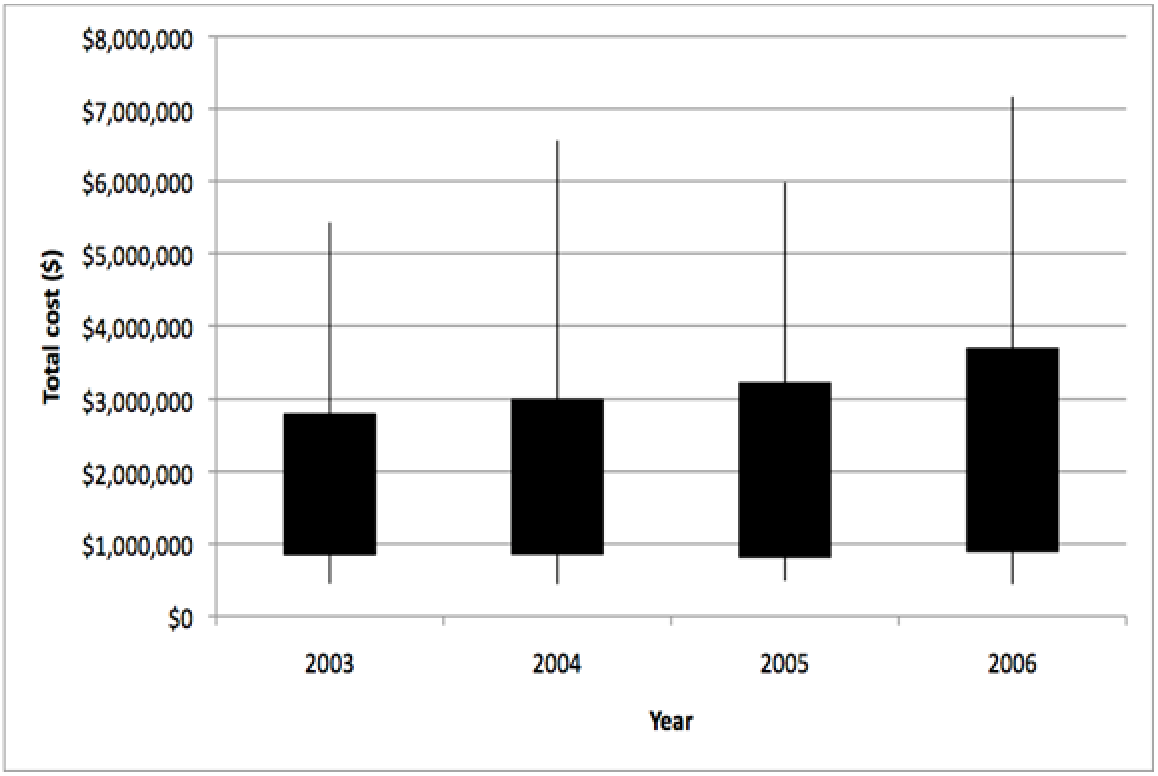

Figure 5.5 Total cost quartiles from 2003 to 2006

Total costs alone are only an indicator of the state of the population, to be meaningful the relationship to production has to be added. A plot of the shifts in cost over the shifts in production demonstrates the overall changes (Figure 5.6). Since there was still variation within the group even with the same firms from year to year, the graph below was produced using contractors representing each quartile in 2006 compared to their earlier production and cost.

The minimum contractor(s) increased production without increasing costs. Those in the first, second, and third quartiles decreased production but increased their total costs. Furthermore, the degree of increased cost was more of a burden on the firms representing the second and third quartiles causing increased marginal costs. Only the firm(s) with the largest production was able to increase both output and costs by roughly the same percentage. There was obviously a variety of coping strategies being employed to deal with the changes is markets and operating costs.

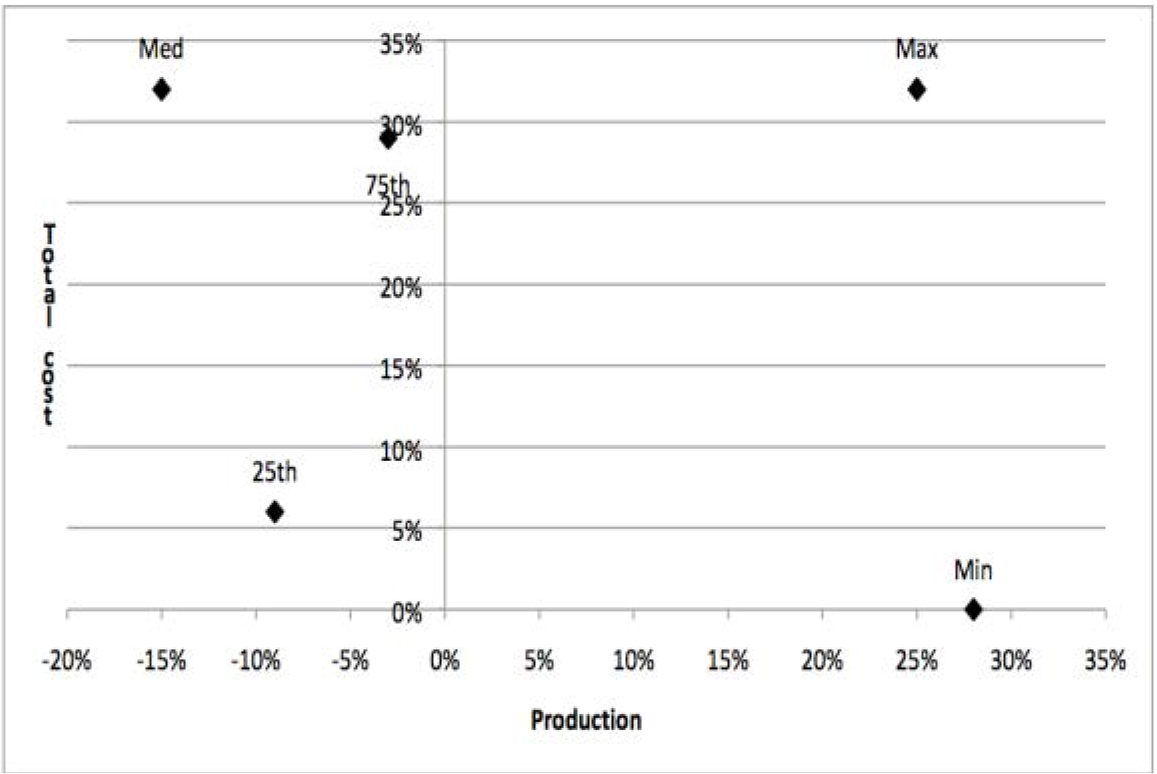

Figure 5.6 Change in production vs. change in total cost over the period.

Total costs alone indicate actions taken by individual firms, but take on an added dimension when linked with business output. The increase in costs ran well ahead of the increase in production between 2003 and 2004 as shown by the scatter plots and increased slopes of the ordinary least squares regressions.

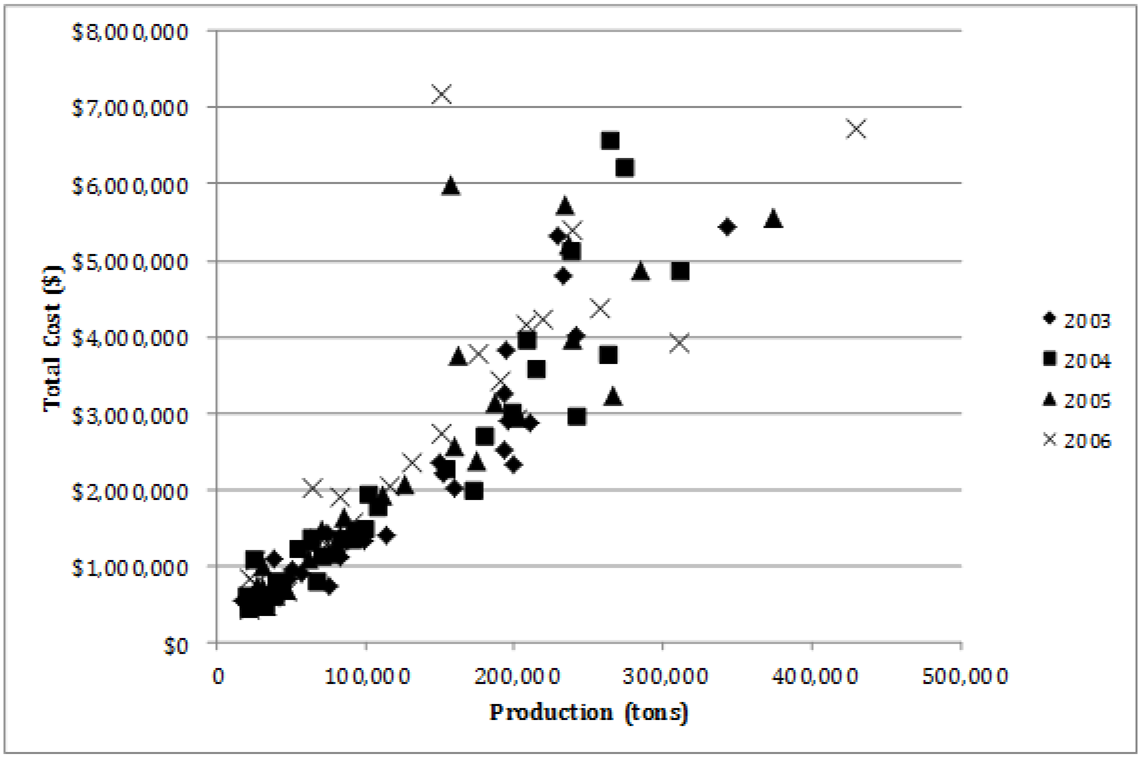

Figure 5.7 Regression analysis of total cost as a function of production

The parameters for each line are shown in Table 5.4. The slope, or variable cost, of production increased between 2003 and 2004 and then pulled back to slightly below the 2003 level in years three and four. The negative intercepts may reflect that these firms were using equipment that had been totally depreciated and were carrying minimal insurance coverage during the first two years and then changed strategy by reinvesting in years three and four. This change in strategy apparently reduced the surety in explaining total costs as simply a function of production, as the R^2 decreased and the intercept turned positive.

Table 5.4 Values of production vs. total cost regression

Year	Slope	Intercept	R^2
2003	16.579	-56645	0.8912
2004	17.606	-53181	0.8581
2005	16.473	238202	0.7855
2006	16.072	411746	0.7406

The regressions reveal that, while business costs were low in 2003 and 2004, most expenses were linked to production but in 2005 and 2006 operating expenses rose significantly. Even though production linked cost decreased in 2006 below the values of 2003, cost per ton increased yearly because of higher continuing expenses. At the beginning of the period, cost per ton averaged $16.71 and by 2006 cost per ton had risen 26% to $21.08. The R^2 range from 0.75 to 0.89, indication that production alone is a primary indicator of costs.

5.3 Labor

Labor cost was approximately 30% of total cost. For individual firms, labor cost varied dramatically, accounting for as little as 9.9% of total cost for some and as much as 52% for others. On a cost per ton basis for the entire population, labor averaged $5.16 in 2003 and increased to $6.22 by 2006.

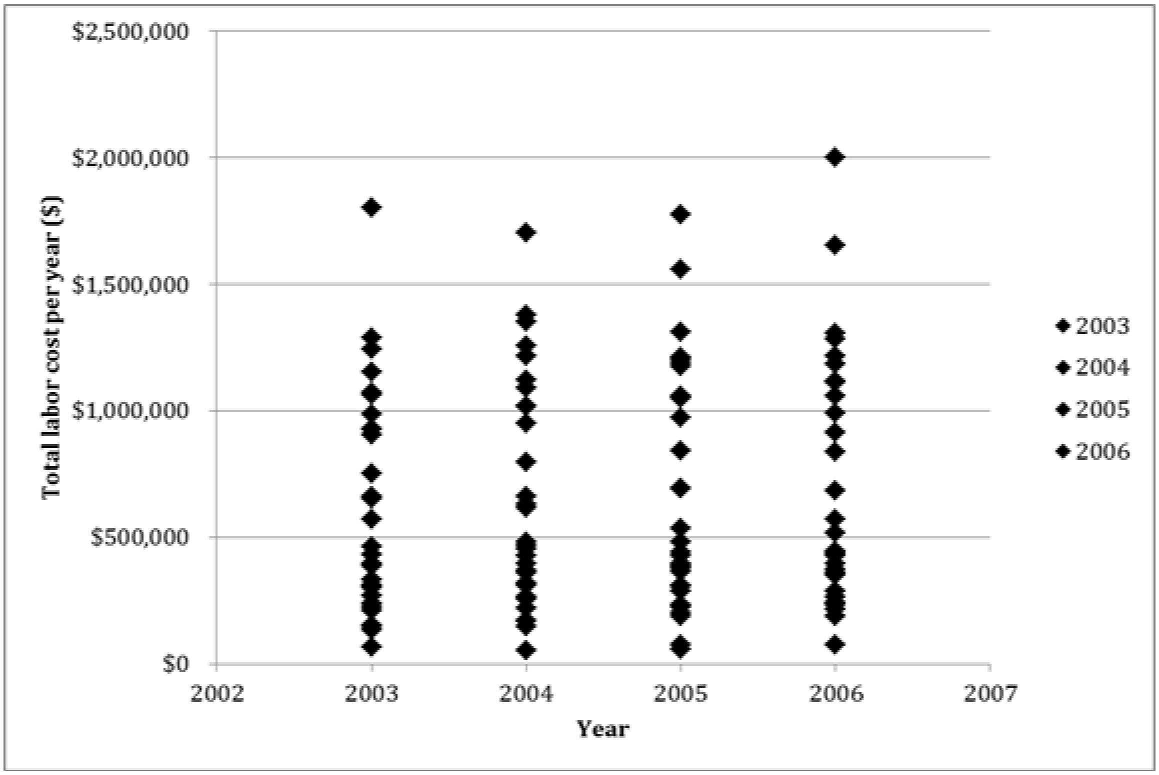

Figure 5.8 Labor cost distributions for 30 contractors from 2003 to 2006

In total dollars, the cost of labor varied from $54,454 to $2,001,254 among firms. The average firm spent $612,311 on labor in 2003 and by 2006 that cost rose to $699,567 or by 14%. The changes from year to year in each quartile are seen in Table 5.5.

Table 5.5 Quartile values of labor cost for 30 contractors from 2003 to 2006

	2003	2004	2005	2006
Minimum	$64,971.96	$54,453.84	$55,856.34	$73,139.91
25%	$277,259.81	$312,723.13	$306,157.58	$303,438.63
Median	$446,768.67	$475,428.91	$461,817.66	$481,970.82
75%	$927,016.74	$1,017,503.67	$1,055,248.41	$1,098,931.11
Maximum	$1,803,062.11	$1,703,264.88	$1,777,268.24	$2,001,253.91
Range	$1,738,090.15	$1,648,811.04	$1,721,411.90	$1,928,114.00
IQR	$649,756.93	$704,780.54	$749,090.84	$795,492.48

Year to Year Change

	2003-2004	2004-2005	2005-2006	Overall
Minimum	-16%	3%	31%	18%
25%	13%	-2%	-1%	10%
Median	6%	-3%	4%	7%
75%	10%	4%	4%	18%
Maximum	-6%	4%	13%	11%

All quartiles experienced an increase over the period with the largest changes in the minimum and the 3rd quartiles. Individually, however, minimum and maximum values were most dramatic from year to year. As shown, minimum labor cost dropped 16% between 2003 and 2004 then increased 31% between 2005 and 2006. Maximum labor cost dropped from 2003 to 2004 by 6% which helped to offset an increase of 13% from 2005 to 2006. Labor obviously was not a contributing factor to the rise in total cost.

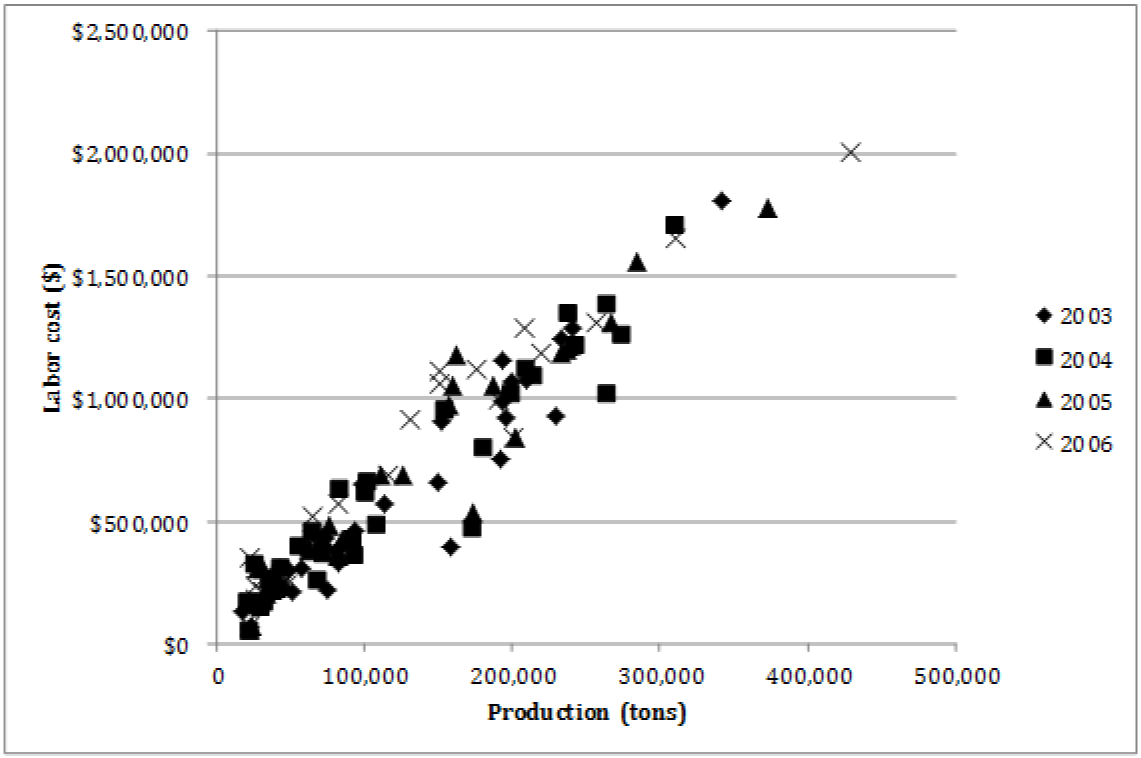

Figure 5.9 Labor cost as a function of production for 30 contractors from 2003 to 2006

The R-squared values for this regression (.909 to .937) suggest that a clear relationship between production and labor cost exists. Slope changed little from year to year ranging between 4.69 and 4.93 suggesting that labor was changed little to affect production. The intercept values increased from $6,782 in 2003 to $105,454 in 2006 revealing one of two things. Either labor became increasingly expensive to maintain regardless of firm output or the use of labor in large firms became more efficient.

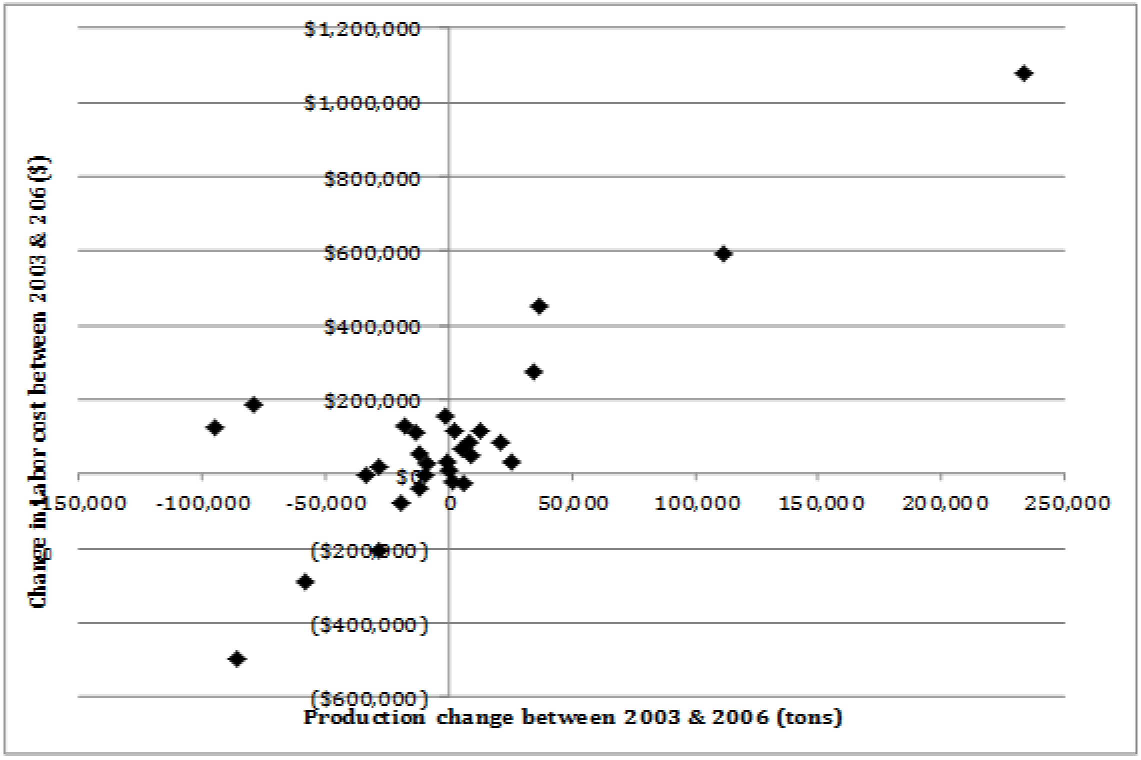

Figure 5.10 Change in labor cost compared to the change in production for 30 firms in the Eastern United States between 2003 and 2006

The majority of contractors ended the period in northeast and southwest quadrants where both production and labor either increased or decreased but at different rates. Increases in labor costs coupled with increased production may benefit firms over time. The extent of the increase, such that of the firm that increased production 250,000 tons and increased labor cost by roughly $1.1 million or $4.40/ton has to be considered in the context of the effect of the change on the overall business position. At least ten (10) firms ended the period in the northwest quadrant with decreased production and increased labor costs. Again, the change was beneficial in the short run only if savings in another cost category, such as consumable cost, offset the increase.

5.4 Equipment

The cost of equipment accounted for approximately 15% of total cost for this population throughout the period ranging from 2% to as much as 40% for individual firms. The actual outlays for each firm are shown in Figure 5.11.

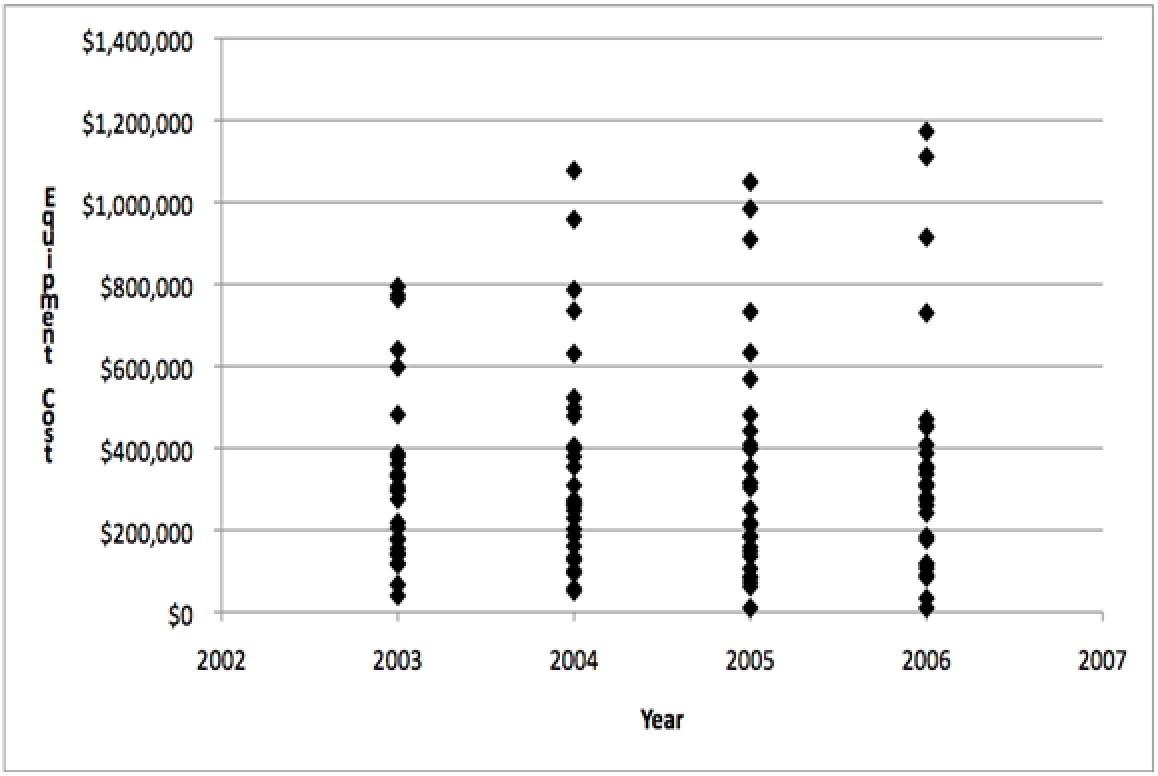

Figure 5.11 Equipment cost distributions for 30 contractors from 2003 to 2006

The average outlay for equipment was $313,921 in 2003 and rose approximately 14% to $358,566 in 2006. Figure 5.11 indicates that the spread increased as the period progressed due mainly to two firms in an expansion stage. Equipment can be manipulated easier than most other costs because firms have the option of different strategies. The first, involves buying new equipment and using it for the depreciable life (or until its value on the used equipment market is sufficiently greater than its depreciated value) then trade or sell it. Firms using this strategy buy new equipment to avoid production loss due to breakdowns and possibly gain from better fuel economy. The second strategy involves buying well maintained used equipment or continuing to use reliable equipment that has been paid off and depreciated out. This strategy results in lower equipment payments but may result in higher maintenance costs and risk of increased lost time due to maintenance and repairs. Finally, equipment costs are generally a function of how the contractor sees his position within the local wood supply system. If he is assured of a continued full time opportunity to produce, he may see the first approach of maintaining a relatively new equipment spread as an advantage. If he faces a fluctuating demand for his services, using older equipment to diminish the continuing costs of his operation would be a better choice. This is reflected in Table 5.6 below. The smaller contractors reduced the amount allocated for equipment dramatically, those in the first, second, and third quartiles expanded guardedly. The fourth quartile expanded because four firms had an opportunity or need to expand/ renew their equipment spread.

Table 5.6 Quartile analysis of equipment cost for 30 contractors from 2003 to 2006

	2003	2004	2005	2006
Minimum	$39,696.28	$50,579.21	$10,073.00	$9,936.00
25%	$146,910.38	$167,138.10	$150,654.33	$178,419.87
Median	$295,539.68	$268,009.65	$308,496.34	$310,782.76
75%	$375,158.83	$460,250.43	$433,576.13	$402,981.00
Maximum	$794,156.04	$1,077,499.12	$1,049,508.23	$1,172,645.82
Range	$754,459.76	$1,026,919.91	$1,039,435.23	$1,162,709.82
IQR	$228,248.45	$293,112.34	$282,921.81	$224,561.13
Year to Year Change				
	2003-2004	2004-2005	2005-2006	Overall
Minimum	27%	-81%	-2%	-56%
25%	14%	-10%	18%	22%
Median	-10%	15%	0%	5%
75%	22%	-6%	-7%	9%
Maximum	36%	-3%	12%	45%

The changes in minimum and maximum equipment cost further demonstrate the market for services prompted the increased range of equipment costs by 54% or $407,000. The large drop in the minimum value between 2004 and 2005 was caused by a firm that maintained production but cut back on replacing equipment. At the upper end, 2006 was the only year where the same contractor had the highest production and the highest equipment cost.

Regression analyses better show the relationship between equipment cost and production. Note the increased spread of data points beyond a production level of roughly 175,000 tons per year. There are several plausible explanations for this. Some of these operations may have purchased additional or new equipment in one year but the associated productivity gains materialized in the next. A second is that the equipment was purchased in expectation of production opportunities that did not materialize. Finally, this may reflect the effect of accelerated depreciation strategies chosen for income tax purposes.

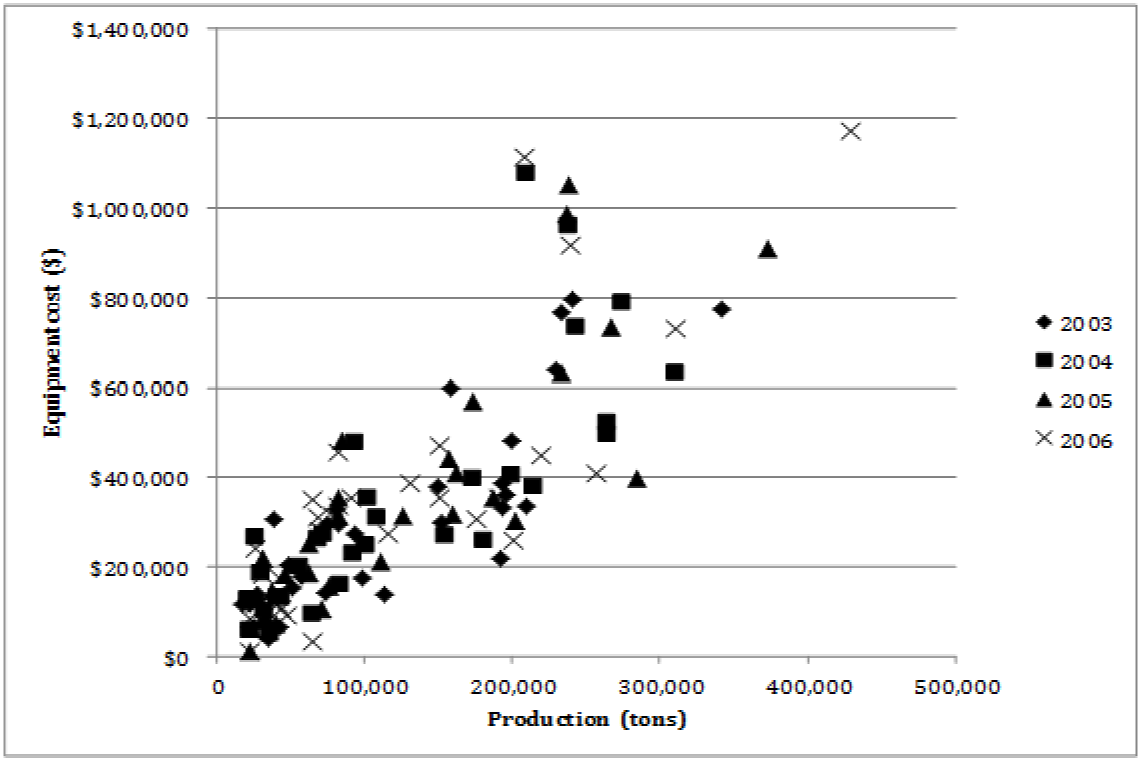

Figure 5.12 Equipment cost compared to production for 30 contractors from 2003 to 2006

Based on R-squared values, production explains about 63% to 70% of the variation in equipment cost. The cost of owning equipment changed little but was highest in 2006. The cost of increasing production by one unit through additional equipment was highest in 2005. Over the period, equipment cost per ton increased by approximately $.30 per ton or 10%. The clustering of points below the regression lines in the $150,000-$225,000 range is interesting, especially given the cluster above the line between $225,000 and $275,000. Unfortunately, insufficient information was available to assess the causes of the anomaly.

Plotting the change in equipment cost against the corresponding change in production demonstrates the effects of different equipment spread management strategies.

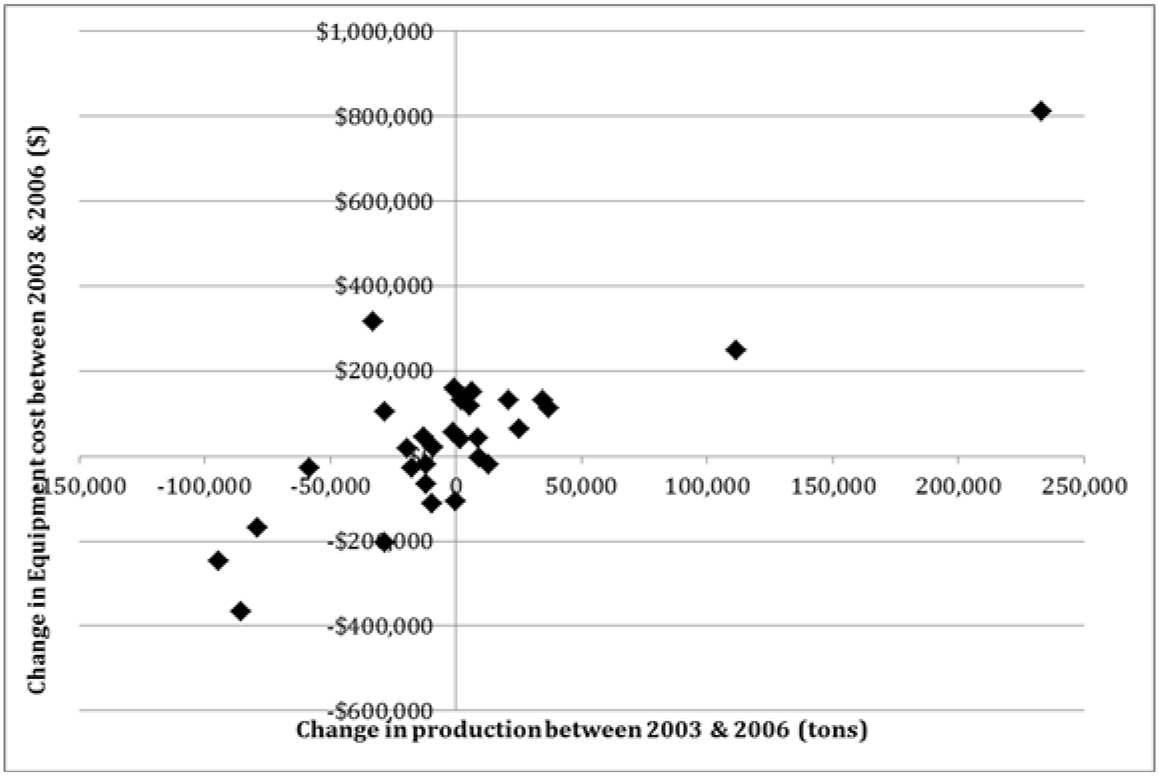

Figure 5.13 Change in production compared to change in equipment for 30 contractors from 2003 to 2006

The chart demonstrates that most operations fell into an area of +/- 50,000 tons per year change in production with a +/-$150,000 change in equipment costs. There was only one borderline case where an operation increased production with a small decrease in equipment costs. The northwest quadrant has seven (7) firms that experienced increased equipment cost with no production increase. As was the case with labor, the largest overall producer increased his equipment cost by approximately $800,000 and increased production by roughly 240,000 tons. Timing is important, especially when planning equipment purchases because natural and market forces such as hurricanes and mill quotas can drive production levels in unanticipated directions. Equipment costs differ from other cost inputs because they are spread over time. Equipment purchases in one year will affect costs for three or more years into the future.

5.5 Consumables

Consumables and contracted service were tied for the second largest cost category by percentage. In 2003, consumables accounted for roughly 21% of total cost and by 2006 had increased to 25%. This cost is tied directly to the cost of fuel, parts and lubricants, which can change very quickly. Average consumable cost increased by $1.86 or almost 40% over the period

Table 5.7 Consumable quartiles for 30 firms from 2003 to 2006

	2003	2004	2005	2006
Minimum	$48,163.30	$53,079.51	$78,921.00	$98,962.39
25%	$182,891.07	$206,934.44	$238,586.43	$267,646.16
Median	$300,445.85	$352,298.37	$426,598.24	$417,094.36
75%	$561,393.10	$625,494.07	$809,177.40	$787,616.50
Maximum	$1,472,674.44	$1,445,689.18	$1,635,547.99	$1,674,831.89
Range	$1,424,511.14	$1,392,609.67	$1,556,626.99	$1,575,869.50
IQR	$378,502.04	$418,559.63	$570,590.97	$519,970.34

Year to Year Change

	2003-2004	2004-2005	2005-2006	Overall
Minimum	10%	49%	25%	84%
25%	13%	15%	12%	40%
Median	17%	21%	-2%	36%
75%	11%	29%	-3%	37%
Maximum	-2%	13%	2%	13%

With the exception of the decrease in two quartiles between 2005 and 2006, all consumable cost quartiles increased over the period, the biggest increase being in the minimum cost. Large firms contend with high consumable cost regularly because of the inventories required to keep operations running. They are also able to spread an increase in cost of consumables over much higher production. Increased consumable cost affects smaller firms most because fuel, lubricants, tires, parts and supplies constitutes a larger share of their expenses.

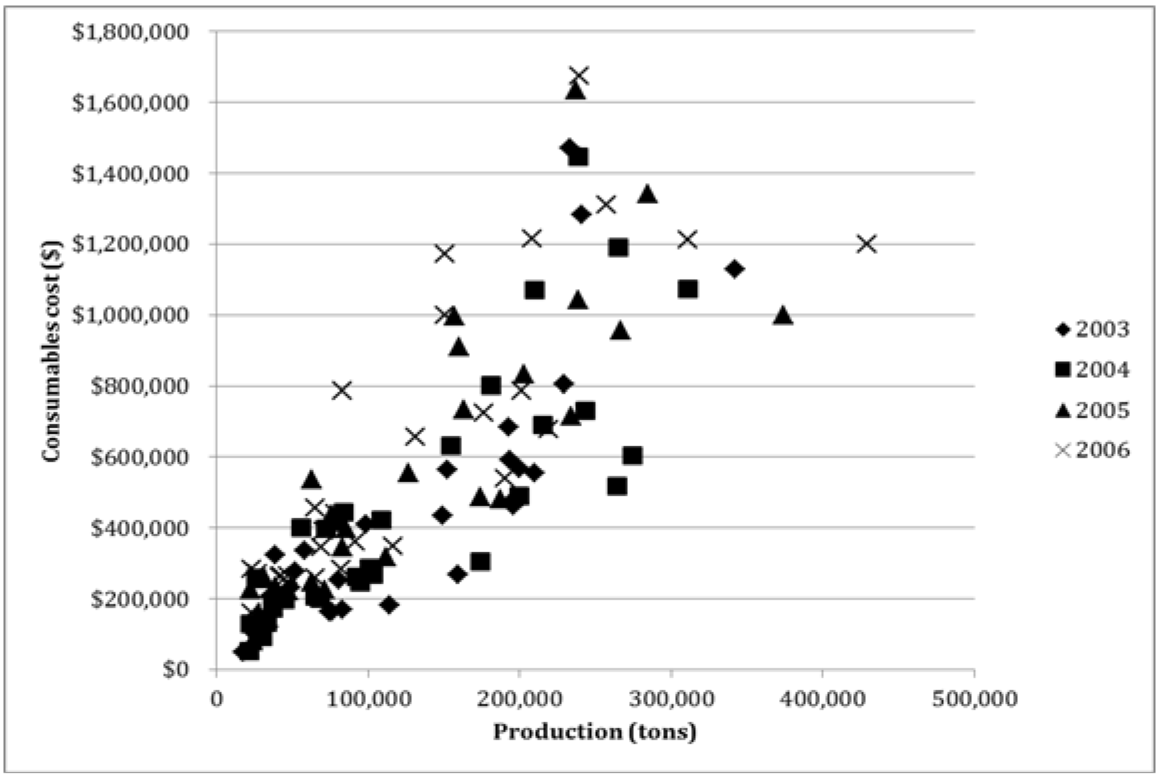

Figure 5.14 Consumable cost as a function of production for 30 contractors from 2003 to 2006

Regressing consumables costs over production provides some interesting insights. First, consumable supplies compete with equipment costs for the widest spread, year to year, in intercept levels. The slope of the lines was fairly consistent for three of the four years. The intercept values reflect that factors other than production, namely crude oil prices, affect these costs. Depending on the type of consumable cost added, production may or may not be influenced. An increase in the amount of fuel used may reflect an increase in days worked, or alternatively having to use the equipment more to move the same amount of wood. Buying a more expensive set of tires for a skidder, however, may allow the contractor to run longer on one set of tires or operate in an area where no other firms can, possibly increasing the need for his services.

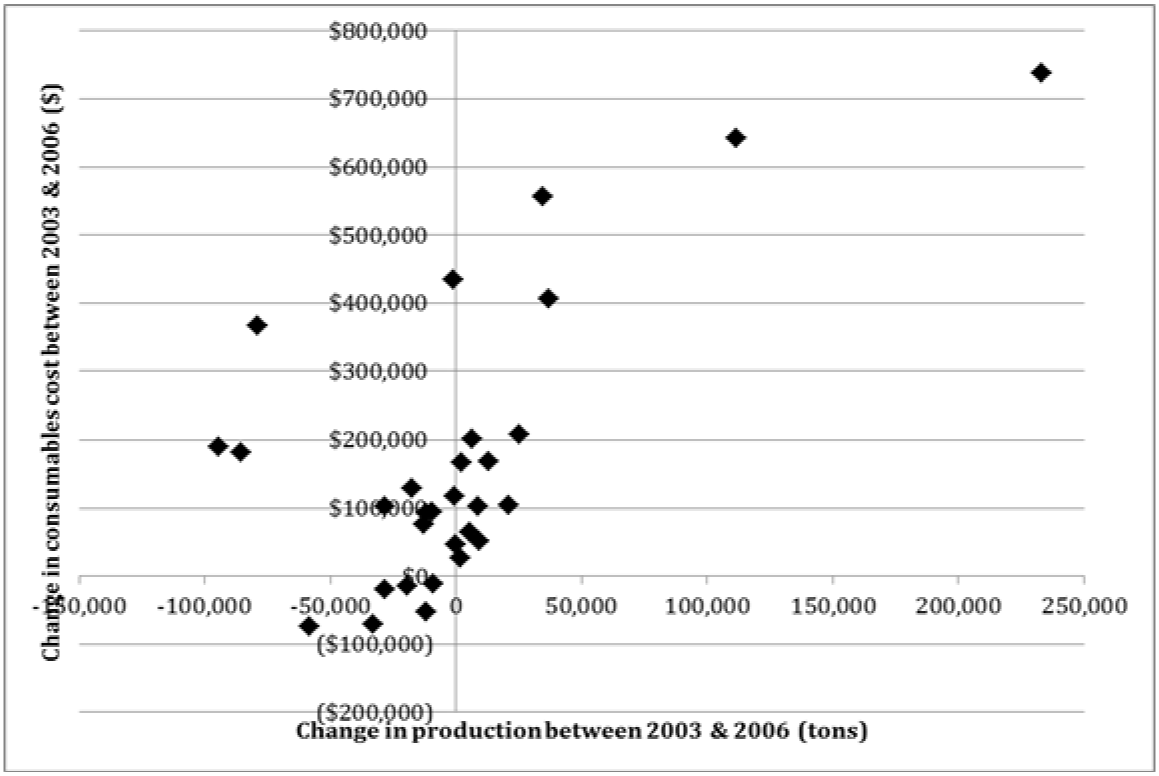

Figure 5.15 Change in production compared to change in consumable cost for 30 firms from 2003 to 2006

Changes in consumable costs were plotted against changes in production (Figure 5.15) and against changes in equipment cost. In both cases, 80% of firms experienced increased consumable cost regardless of changes in production or equipment investment strategies. The increased price in petroleum products obviously affected consumable supplies costs more than production or additional cost in other categories. Rather than cost increasing because of increased inventories, price simply increased and firms paid more per unit for the same amount of consumables.

5.6 Contracted services

This category may be considered as a substitution for expenditures in other areas –equipment, labor, consumable supplies and insurance. The use of contractors avoids the long term commitment of borrowed money when buying equipment, and the commitment of employment to labor. Median cost was $247,115.74 in 2003, rose to $258,669.38 in 2005 and dropped to the lowest level in 2006 at $196,118.40. Average costs for contracted services, however, increased each year, suggesting that larger firms increased their use of sub-contractors.

Table 5.8 Contracted services quartiles for 30 firms from 2003 to 2006

	2003	2004	2005	2006
Minimum	$0.00	$0.00	$0.00	$0.00
25%	$75,168.86	$106,055.08	$64,542.94	$74,123.23
Median	$247,115.74	$256,767.87	$258,669.38	$196,118.40
75%	$713,904.99	$661,436.13	$760,396.10	$808,970.32
Maximum	$2,789,031.17	$3,579,843.34	$3,238,525.42	$4,164,517.13
IQR	$638,736.13	$555,381.05	$695,853.16	$734,847.09

Year to Year Change

	2003-2004	2004-2005	2005-2006	Overall
25%	41%	-39%	15%	17%
Median	4%	1%	-24%	-19%
75%	-7%	15%	6%	14%
Maximum	28%	-10%	29%	47%

Some firms chose not to sub-contract road building or hauling timber to mill so the minimum quartile did not change. The first quartile (25%) had the largest percentage changes year to year but increased only 17% over the period. The maximum had the largest percentage increase overall the result of a 28% increase from 2003 to 2004 and 29% between 2005 and 2006 overwhelming the 10% decrease from 204-2005. The majority of contracted services were hauling, so regression analysis shows only a modest relationship between production and contracted services, because factors affecting haulage costs – distance, road quality, weight limits, and mill turn around time are largely independent of tract characteristics. R-squared values varied between .248 and .47 suggest that there is not a strong relationship between production and contracted services outlays but rather simply a contractor's business management strategy.

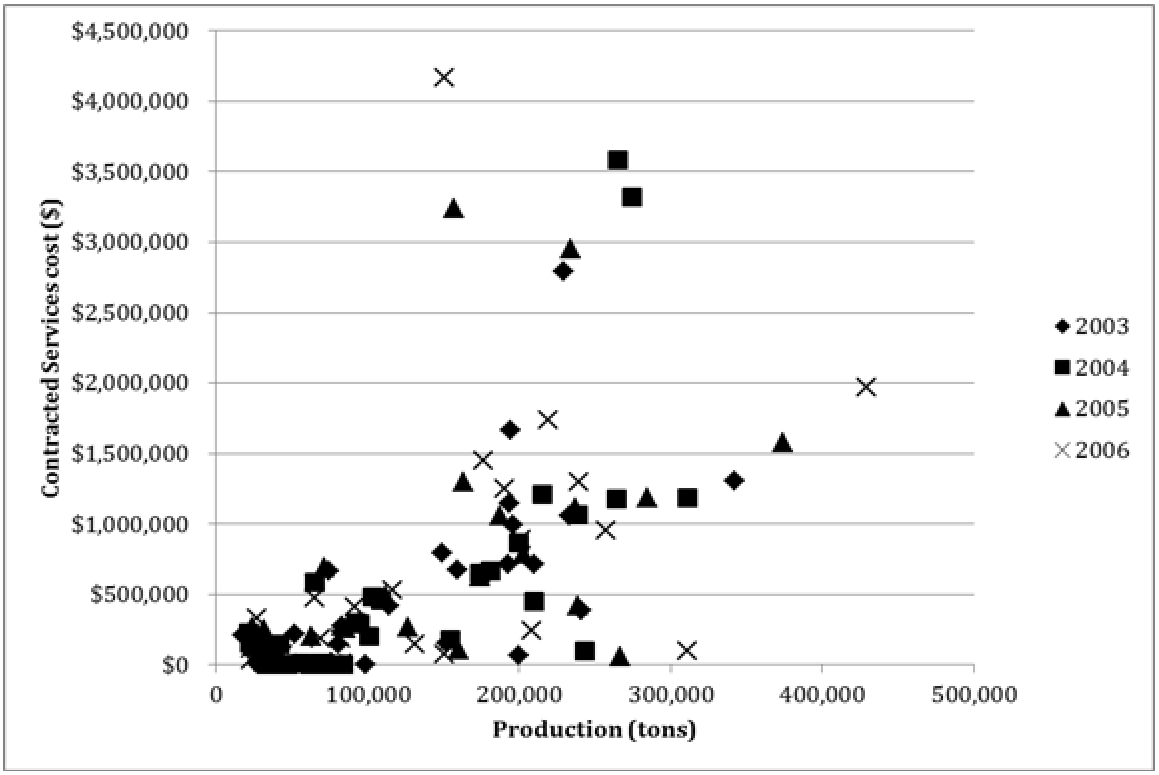

Figure 5.16 Production compared to contracted services for 30 firms from 2003 to 2006

The graph above (Figure 5.16) shows that larger firms, those producing 150,000 to 300,000 tons per year were more likely to contract out hauling and secondary activities such as road construction.

5.7 Administrative Overhead & Insurance

Both Administrative Overhead (AOH) and Insurance accounted for approximately 3% of total cost. Over the period, Insurance costs totaled $9,002,397 and AOH costs totaled $7,667,722. On a yearly basis, each cost category was highest in 2006 with approximately $2.4 million spent on Insurance and $2.1 million spent on AOH. Cost quartiles for each category are shown below and show a measure of the changes from year to year.

Table 5.9 Insurance cost quartiles for 30 firms from 2003 to 2006.

	2003	2004	2005	2006
Minimum	$12,621.40	$13,779.00	$13,266.00	$14,202.50
25%	$29,446.38	$32,733.58	$37,359.55	$37,203.71
Median	$54,779.72	$63,158.41	$68,837.40	$58,383.36
75%	$93,982.72	$98,980.26	$106,518.93	$128,161.31
Maximum	$201,493.85	$182,117.54	$188,296.45	$200,282.51
IQR	$64,536.33	$66,246.68	$69,159.38	$90,957.60
Year to year change				
	2003-2004	2004-2005	2005-2006	Overall
Minimum	9%	-4%	7%	12%
25%	11%	14%	0%	25%
Median	15%	9%	-15%	9%
75%	5%	8%	20%	33%
Maximum	-10%	3%	6%	-1%

Over the period, each quartile showed an increase in insurance cost except for the maximum quartile. The maximum total cost increased 32% (shown in Table 5.3) equating to an additional $1,736,306. Over the same time, the 33% increase seen in the 75 percentile of Insurance cost only equated to $34,179 in actual dollars. Although Insurance is important to the overall system, seemingly large changes in this category are not as dramatic as smaller increases in larger cost categories. Nonetheless, Insurance cost increased over the period and it is necessary to determine the cause.

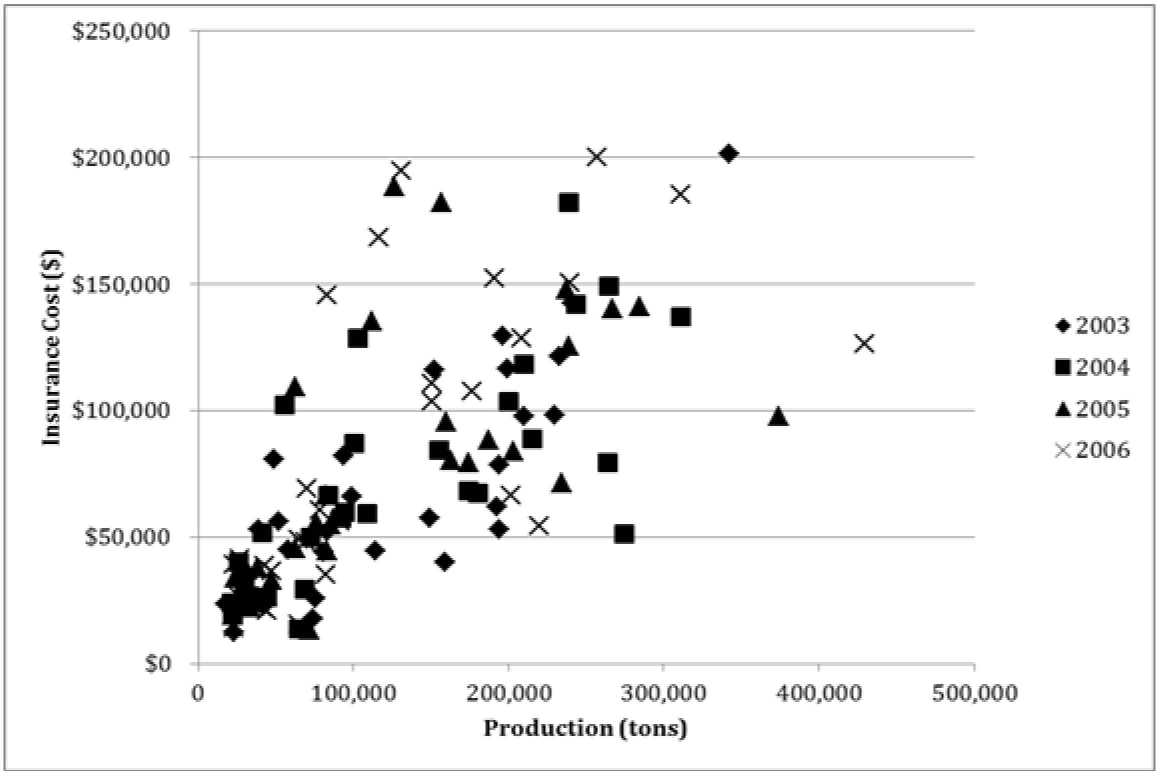

Figure 5.17 Insurance compared to production for firms production less than 150,000 tons from 2003 to 2006.

The group was split at the 150,000+ ton mark in production and Insurance costs were regressed against production for both sub-groups. Variation in Insurance cost was explained more by the production levels of smaller firms. Negative intercept values shown in Table 5.10 are likely mathematical anomalies associated with fitting a straight line to a curvilinear relationship.

Table 5.10 Regression values for insurance cost against production for smaller firms from 2003 to 2006.

	Slope	Intercept	R-squared
2003	0.3731	19275	0.2537
2004	0.6582	9723.6	0.4176
2005	1.143	-12095	0.6118
2006	1.3584	-24697	0.6594

Table 5.11 AOH cost quartiles for 30 firms from 2003 to 2006.

	2003	2004	2005	2006
Minimum	$4,878.60	$5,514.00	$5,081.00	$4,796.94
25%	$20,424.60	$26,428.49	$23,127.95	$23,852.87
Median	$37,995.28	$50,138.12	$34,548.73	$50,514.74
75%	$84,297.61	$106,557.57	$98,570.86	$116,469.79
Maximum	$215,274.48	$179,111.03	$234,423.00	$251,346.51
IQR	$63,873.01	$80,129.09	$75,442.92	$92,616.93

Year to year change

	2003-2004	2004-2005	2005-2006	Overall
Minimum	13%	-8%	-6%	-1%
25%	29%	-12%	3%	20%
Median	32%	-31%	46%	47%
75%	26%	-7%	18%	37%
Maximum	-17%	30%	7%	20%

AOH costs increased significantly over the period and changed drastically from year to year. Once again, in actual dollars changes were not as large as those in other categories. The largest change, 47% in the median, represented an increase of $12,519. Maximum AOH cost increased 20% or $36,072. The cause of this increase is explained by the rising total cost and increased production. Regressing AOH cost to production and total cost revealed the values shown in Table 5.12

Table 5.12 Results of regression of AOH cost against production and total cost.

Production	Slope	Intercept	R-squared
2003	0.4903	-3185.6	0.6259
2004	0.3929	13756	0.5479
2005	0.5165	53.098	0.6832
2006	0.503	8254.8	0.6184
Total cost	Slope	Intercept	R-squared
2003	0.0272	3183.8	0.5942
2004	0.022	15549	0.6229
2005	0.0294	-2927.3	0.7645
2006	0.0287	1545	0.7029

R-squared values indicate that the majority of variation in AOH can be explained by both production and total cost. Since AOH is largely costs associated with record keeping it is expected that as production and total cost increases so will the amount of paperwork and time needed to monitor and track those increases. This assumption is confirmed by increased R-squared values for AOH against production at the 150,000+ ton mark.

5.8 Conclusions

Over the period, production of the entire set increased in both value and range. Firms with medium production levels were gradually moving to the ends of their production spectrum and some decreasing production to lower operating costs others increasing production to take advantage of lower marginal operating costs.

Total cost increased year to year as a result of increases in labor, equipment and consumable cost categories and also due to increased cost of contracted services by large firms. From 2004 to 2005, small and medium sized firms began re-allocating resources to deal with drastic increases in consumables cost while large firms tried to offset the rising cost with changes in production. Insurance and AOH, both related more to fixed rather than production costs, increased for all firms over the period.

The economic impact logging has on rural communities can be quantified by the totals of different cost categories over the entire study period. Total labor cost of the population was $93,852,840 over the period and Contracted Services cost was $81,107,740. These expenses, given as income to employees and contractors by logging firms, were largely re-invested in local economies. Equipment cost $48,626,694 which meant expenditures for new equipment purchases to dealers and banks or other lending agencies and interest payments stayed close to home. Fuel suppliers, tire dealers and parts retailers received part of $71,194,628 spent on consumable supplies. From 2003 to 2006 a total of $314,864,784 was spent in rural communities and, either directly or indirectly, logging firms contributed to the cash flow of grocery, clothing and convenience stores, equipment dealers, lawyers, accountants, hospitals and restaurants. Furthermore, their production of 18,293,312 tons of raw forest products went to dealers and mills that drew income from producing finished products.

CHAPTER VI

©COMMERCIAL APPLICATION

6.1 2008

A company based in Mobile, Alabama owned 4 mills that produced chips for foreign paper markets. Originally, the company wanted to find out how much logging would cost or how much they had to pay for logging so "what if" scenarios were used to understand the expenses incurred by contractors and the results of shifts in those expenses. The main benefit of this application was it showed the elasticity of cost per ton when individual categories changed. First, the six cost categories were listed with an explanation of the expenses in each category as well as a discussion of the types of variation firms could face. The next step was to select firms from the database that represented the firms contracted by each mill. The first firm selected was a small firm in the Appalachian region to demonstrate the effect of increasing one cost category without increasing production.

Table 6.1 Differences in total cost and cost/ton when consumables cost increase 5% with no change in production

Before		After		Change	
Total Cost	Cost/ton	Total Cost	Cost/ton	Total cost	Cost/ton
$1,063,012	$39.95	$1,076,624	$40.10	↑ $13,623	↑$0.51

Table 6.2 Difference in total cost and cost/ton when production and consumables cost increase 5%

Before			After			Change	
Production	Total Cost	Cost/ton	Production	Total Cost	Cost/ton	Total cost	Cost/ton
26,850	$1,063,012	$39.95	28,193	$1,076,624	$38.19	↑ $13,623	↓1.40

In this situation, if an increase in consumables led to additional production the extra expense is beneficial over the long term. This scenario was also useful in explaining a common misconception of procurement foresters which is that increased costs are negated by slight increases in rates. The company had increased their rates as a response to fuel costs in months past but saw quickly that it did little to help their contractors' bottom line.

Several other scenarios were developed with the same concept in mind. Using medium and large firms as well as firms in the Coastal Plains regions, some general information was gained. By manipulating the data in a controlled fashion, the company was able to gain insight into how a change in the same cost category could affect firms differently. After spending some time with the cost data of actual logging firms, their question became how can we better prepare or assist in the changing costs of our logging contractors.

6.2 2010

A wood buying firm in Philadelphia, Mississippi also held ownership in a logging firm supplying a large lumber mill. Using the knowledge gained from this research, we were able to answer two main questions. First we re-organized the cost analysis for the logging firm. Every cost was placed into one of the six cost categories to facilitate comparison with the database and to simplify cost tracking. After re-organization, we began analysis to answer the questions below.

6.2.1 Question 1: What does it cost me to move?

Based on the information supplied, average production/day was 1,126 tons. He estimated that moving usually took a whole day but equipment was moved so that at least one piece was running, if possible. He was also fortunate to be working for a mill that organized his tracts in a manner that reduced long distances when possible. In the worst possible case, moving would have cost this firm almost $20,000 in income from lost production. Given the opportunity to work five full days per week and every other Saturday, his average production would fall almost 250 tons and decrease moving costs by $4500. However, given the procurement system this contractor was in, moving never cost a whole days production. Moving costs were calculated based on the lost production from parking or moving individual equipment and the real values were significantly lower over a 6 month period following.

6.2.2 Question 2: Can I actually make up a missed day?

To answer this question, we used comparative data gained from a contractor in Alabama. This contractor had relatively the same level of production as our MS firm but had slightly more variation in weekly totals. The AL contractor averaged 4,115 tons per week and a range in production of 4,839 tons. Actual weekly production and cumulative variation are seen in Figure 6.1.

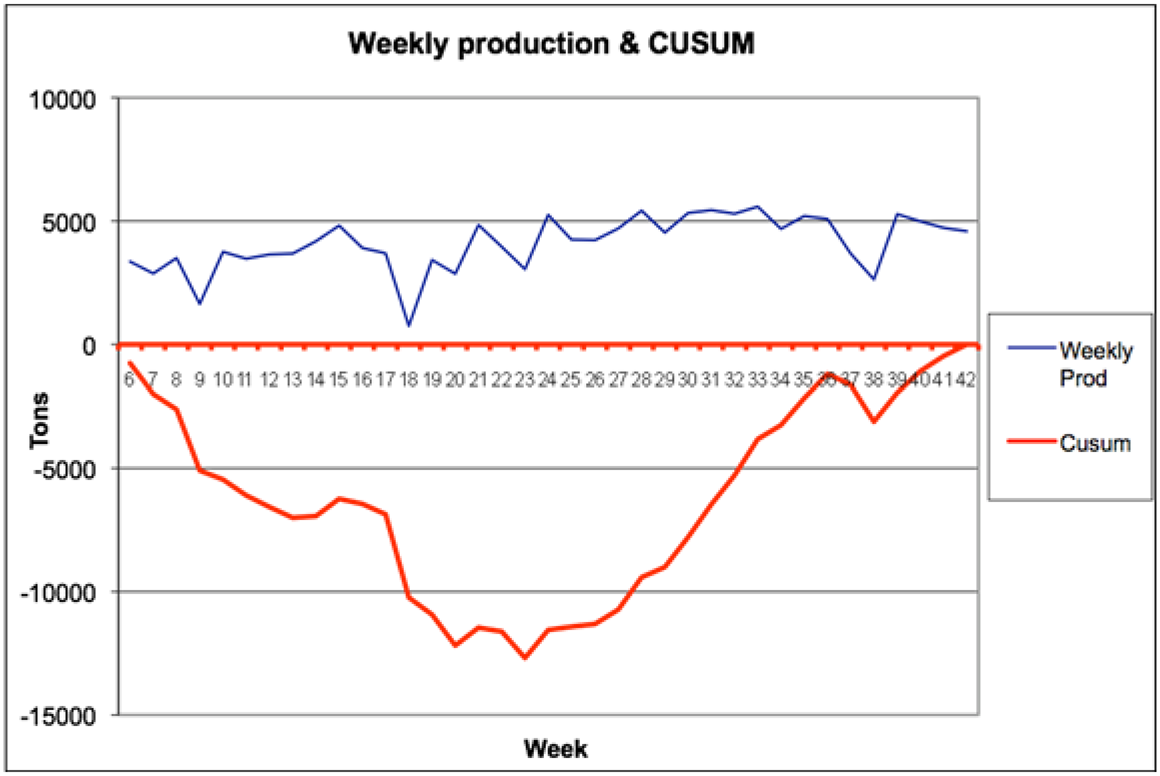

Figure 6.1 Weekly production and Cumulative Summation for an Alabama contractor

Based on average production, the AL firm was unable to "make-up" lost production. Under normal circumstances, the contractor would have been able to produce roughly 4,000 tons per week. This measure of efficiency helped our MS firm see the difference between missed days and lost production.

The answer to this question was ultimately specific to the contractor. The owner had a set production that he wanted to meet each week and he used catch-up days to reach that level. Although his operation was production oriented, he was not pushing to get maximum production.

6.3 Conclusions

Even though industrial applications have not been identical to the analysis of the initial project, information gained has been useful in bridging the gap between landowner, logger and mill. It has helped loggers see how their operations compare to others related to size and location, how they may improve their operations analytically and mechanically, and how production management can hinder or help their firms. It has been an important tool in showing mills how their management and procurement strategy can be organized to help the logger be production and understand, graphically, the effect of moving a logger and the effect tract size can have on a contractor based on the size of the firm. Although some steps have been made in uniting the entire wood supply system some questions still remain and will likely continue to develop as long as business men employ their skills in the woods to connect landowner and mill.

To reiterate the points made earlier, the independent contractors' businesses show the same amount of variation as the system they operate in. With the volatile economic climate of the present day, these firms' economic and social importance grows because they continue to provide jobs and give families everyday needs in the midst of financial uncertainty. Although most industrial research focuses on the cost centers of these firms, perhaps more should be done to insure their continued growth and, at the very least, their sustainability. If these firms and companies like them continue to deal with high market fluctuations and uncertain returns on investment, they will continue to leave voids in the overall wood supply system and landowners and mills will have no support.

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