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Forest Development and Its Impact on Rural Poverty

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Forests and rural poverty seem to go hand in hand. Where we find one, we often find the other.

- In China, more than 90 percent of the poor live in rural areas and 496 of 592 officially designated poverty stricken counties are in mountainous, forested regions (Zhang *et al*. 2004; MOF 1995, as cited in Ruiz Perez *et al.* 2003).
- Rural poverty exceeds 35 percent in PNG and Mongolia, the countries with the largest forest areas per capita in East Asia and the Pacific (Magrath 2004).
- The poorest countries in four of five continents have more forest cover than the continental averages.[1]

Even in developed countries like the US and Canada, typically the most remote parts of the country are forested and the local populations are poor. In many countries, these regions of forest and poverty are also the homes of native or ethnic minorities who are not only poor but also disadvantaged in modern society on basis of their ethnic difference.

Improving the condition of the poor in general is a primary global policy issue. Foresters are interested, for their part, in what their professional knowledge and their sector of the economy can do for the particular group of poor people who live in or near the forest and who rely on it as a central part of their existence.

The objective of this paper is to examine that issue: What can forest development do for the rural poor? The pattern of forestry and successful development is well known and the examples are numerous. There is also a developing literature on successful local participation in forest enterprise. We will review illustrative examples for each of these, and then consider the experience of the Mekong Basin countries of Lao PDR, Cambodia, and Vietnam as they present opportunity for forest-based development. Our focus will be on timber and related wood products because these have the greatest market values and there is more evidence referring to them. An appendix will review more briefly what we know about non-timber forest products.

Our intention is to identify the characteristics of successful combinations of forest-based development and poverty reduction. What do these characteristics suggest

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[1] Countries with less than US$150 per capita income in Africa, less than US$400 in Asia, and less than US$1000 in the Americas (compiled from FAO 2001).

for policy in general, for external donor assistance in particular, and especially for the potential of forestry and poverty reduction in the Mekong Basin?

We will observe that a forest resource can be a primary means to sustainable development, but only under specialized conditions of

- access to markets and external demand for primary forest products and
- appropriate incentives for local market participants, including
    - secure rights to the product of their investment and their means of producing and processing forest products and
    - economic and political stability.

We will observe that the poor do benefit under these conditions—with greater personal wealth and, eventually, better employment opportunity. However, a caution is in order. That is, while the very poor do benefit—and that is crucial for our interest—the very poor are not the greatest benefactors. Other income groups tend to benefit more. For the Mekong Basin in general, we will observe improvement in the conditions that anticipate successful forest-led development and we will anticipate that some parts of the Basin contain good opportunity for forest-based development. Nevertheless, there is room for further improvement. And further improvement in these conditions will have favorable effects on poor households, rural development, and the sustainable contribution of some forest activities in the Basin. It is toward the improvement in these fundamental market and policy conditions that local policymakers and international donors can make their own most important contributions.

The General Experience

If poverty and forest cover occur together, then can the forest resource be a means for reducing poverty? In fact, there are many examples where forest extraction led successful local economic development. However, it is clear that the simple existence of extensive forest cover does not imply opportunity for financial gain and development. Furthermore, it is also clear that financial gain from forest extraction does not automatically assure regional development. The interior regions of northern Canada, Siberia, and the Amazon have almost endless expanses of forest. Yet those resources have minimal market value and minimal impact on regional development today. In other regions and times, large quantities of valuable timber were removed from the Lake States of the US in the 1880s, from Cameroon in the 1990s, and from the region of Siberia bordering Heilongjiang Province of China even more recently, all with great financial gain to some participants but little impact on local development.

Therefore, the first step in addressing our question is to identify the characteristics of successful forest-led development and, in contrast, the underlying characteristics of success that were absent from those examples of forest extraction that have not been a part of successful regional development? Questions about the rural poor follow. How were they affected in the examples of successful forest-led development? Did they

benefit? And what conditions describe those cases of forest-led development that have had the most favorable impacts on the poor.

We'll begin by considering three examples of forest-led development. The first traces the growth of the forest sector in the US South over the course of the 20th century. The second compares development in three mill centers in the eastern Amazon of Brazil. This second example is more analytical than the first but for a briefer period in the 1990s. The third traces the development of bamboo production and processing in six counties in China. Bamboo is a forest product that substitutes in many of the same uses as timber. Yet its markets in China are less constrained by government administration than the markets for wood and wood products. Therefore, the bamboo sector should be roughly illustrative of what China's timber markets would be if they were less administered. This third example is especially useful for its examination of impacts on household welfare, a topic that has not been as fully examined as some others in the forestry literature. Finally, we'll draw our own summary conclusions about the patterns of forest development and its effects on household welfare from the three examples and from related observations elsewhere, before reflecting on the match between the Mekong Basin and these experiences.

The US South[2]

The US South is the home of the most technologically advanced forestry sector in the world. Forests cover 86 million hectares or 55 percent of the southern landscape. They account for approximately two percent of the world's total forest but Southern forests include fifteen million hectares of plantations, or eight percent of the global total (USDA Forest Service 2000, FAO 2001). The South's shares of the world's commercial forests and of those forest plantations strictly devoted to commercial timber production are larger yet. Southern forests produced fifteen percent of the world's harvest of industrial wood in the late 1990s. Most of their production supplied the South's fourteen thousand mills and untold furniture manufacturers, including some of the largest and most technologically advanced sawmill, plywood, and pulp and paper facilities in the world. At least **XX southern pulp and paper facilities, for example, exceed one million tons in annual capacity.** Two components of the forest industry, lumber and wood products and paper and allied products, combine to form the largest single industry in the South today.[3] The third component, furniture, is also larger in the South than in

[2] This section relies on Williams (1989) and Hyde and Stuart (1999), revised with more recent data from the USDA Forest Service, USDC Bureau of the Census, and the Food and Agriculture Organization of the UN.

[3] Most countries follow an international standard for income accounting (the International Standard Industrial Classification or ISIC). The ISIC identifies these three major (or two-digit) industries within the the forest products sector. Furniture, however, poses difficulties for forestry assessments because it includes metal furniture and metal furniture is a large part of that industry in many countries. Furniture is also the smallest of the three forest products industries in most countries. Therefore, we can concentrate on the other two and still capture the majority of whatever distinguishes the full forest products industry in most countries. Within the ISIC, the full forestry sector is generally divided into forestry itself and forest products. Forestry is tree management. Forest products starts with logging and includes all primary processing.

any other region of the US. The lumber and wood products and paper and allied products industries employ almost 700,000 workers who produced products with **an annual value greater than $XXX in 200x**. The industry exports most of its products to markets in other parts of the US and the world.

The South's Four Forests: The forest sector was not always so important to the South's economy and southern forestry was not always at the forefront of global forest technology. Southern forestry evolved from an extractive activity to a timber management activity over the course of the 20th century.

Foresters speak of the South's "four" forests. The First Forest was the mature natural forest known for its tall stands of clear longleaf pine. The initial harvests from this forest followed the pattern of agricultural development—expanding inland from the Atlantic and Gulf coasts with the conversion of forestland to agricultural production for cotton, tobacco, and rice. The labor supply for the early forest industry was also associated with agriculture. Most loggers were farm workers in search of supplemental income.

The early southern industry relied on the region's rivers to transport logs to sawmills along the coast. These coastal mills were oriented toward export markets. The development of railroad logging in the region changed this orientation as railroads enabled overland access to the northeastern and midwestern US markets and allowed penetration to previously inaccessible regions that became inland logging and sawmill centers.

Rail construction itself became a large share of the total cost of the logging operation and, once the rails were in place, rerouting was unlikely. Therefore, the cost structure of railroad logging encouraged concentrated and integrated logging and sawmill operations. These operations developed their own demands for a reliable and permanent labor force, and a pattern of company towns emerged. Meanwhile, land ownership also became concentrated—with 925 landowners accounting for more than one-half of the region's standing timber in 1919. Just 67 landowners accounted for half of that half.

By 1919, the cumulative affect of prior harvests accounted for more than forty million hectares of cutover forestland across the South. The land area in agriculture peaked and the demand to convert more of the original natural forest to agriculture declined. Southern lumber production declined as a result. In the 1920s, after about two decades of operation, many larger operators "cut and ran", liquidating their holdings, closing their mills, and moving to the US West.

The cutover lands did not remain in that condition for long. Southern pines are aggressive pioneering species and the southern pine forest regenerated naturally on abandoned land. A natural crop of "old field pine" became the South's Second Forest. It became an important source of raw material for the sawmills of the 1930s and early 1940s and also for the emerging pulp and paper industry.

The gasoline engine and electricity changed the industry again in the 1930s and 1940s. The region's sawmills took advantage of both technologies, of the labor force that was left behind when the large concentrated operations departed the region, and of the more dispersed and depleted forest that was left after railroad logging had run its course. Trucks replaced railroads for hauling logs and they opened many smaller pockets of timber that were inaccessible and unprofitable for railroad logging. Logging operations themselves became smaller and more versatile. The complementary development of more mobile electric sawmills enabled the South to continue to supply approximately 35 percent of total US lumber production.

Meanwhile, an emerging pulp and paper industry also drew on the South's Second Forest. The new sulfate pulping technology made it possible to produce pulp from resinous southern pines. The Roanoke Rapids mill opened in 1909 in Virginia's coastal plain. Fifteen more mills followed through the 1930s, all in the South's coastal plain and all manufacturing kraft paper. (The South's first newsprint mill did not appear until 1940—after the industry learned that young southern pines are free of resin.) Many of these kraft mills relied on sawmill waste for a significant share of their fiber supply but this source was dwindling. Even these early paper mills were large capital-intensive operations and, unlike sawmills, they could not be transported to regions of greater supply once the local sources of fiber ran out. A sustained local supply was vital to their continued operation. In response, a few larger industrial landowners began to reforest their own operations (Urania Lumber Co. in Louisiana, Chesapeake Co. in Virginia, Crossett in Arkansas, Great Southern-Gaylord-Crown first in Louisiana then extending to Mississippi).

The South's Third and Fourth Forests: The South's Third and Fourth Forests are known for their plantations. The plantations of the Third Forest were established with wild seed stock in the years following World War II. Those in the Fourth Forest, beginning in the mid-1960s, were planted with selectively improved seedlings. Of course, plantations have never accounted for the majority of the southern forest. Plantations were unnecessary while there was a plentiful supply of natural timber and, even today, plantations only account for seventeen percent of all southern forestland. The inventory of naturally growing timber remains substantial—although it is not always composed of preferred species in advantageous locations.

Following World War II, the larger sawmills continued the exodus from the South that began in the 1920s and the pulp and paper industry continued its search for fiber. Smaller sawmills continued to replace their larger predecessors. These smaller mills were mobile operations, often composed of little more than circular headsaws powered by a farm tractor. They took advantage of remaining pockets of timber wherever they could be found, and of off-season farm labor.

Meanwhile, pulp and paper gradually replaced lumber as the dominant component of the southern forest industry. Value-added in pulp and paper exceeded value-added in sawmills and planing mills by the early 1950s, and the expansion of the pulp and paper industry has continued to this day.

Labor scarcity drove the subsequent technological adjustment. Agriculture mechanized, the aggregate regional demand for labor declined, and much of the rural population emigrated. The forest industry had to increase wages in order to maintain its work force, and higher wages became an incentive to mechanize. Mechanized logging was the result and it became more competitive in the 1950s and 1960s.

It helped that pulpwood demand was outpacing sawtimber demand. Pulpwood is smaller and lighter than sawtimber, and lighter and more uniform products are easier to mechanize. Even the new studmills and plywood mills that began appearing in the 1960s relied on smaller raw material. New capital investment in logging increased fourfold in real terms between 1954 and 1972. It doubled in sawmills and planning mills, increased 12-fold in plywood and structural members, and doubled in paper and allied products. Labor productivity, a measure of increasing mechanization, more than doubled in sawmills and planning mills and more than tripled in logging, in plywood, and in pulp and paper between 1954 and 1972.

Mechanization continued at a rapid pace over the last quarter of the 20th century. The level of new capital investment in lumber and wood products first increased, and then tapered off at a level that is still fifty percent greater in real terms than it was in the 1960s. New investment continues at a rapid rate in plywood and structural members as the construction industry shifts away from plywood as a structural material, and as new substitutes like oriented strand board (OSB) find ways to utilize the plentiful upland hardwood resource. The seven large new OSB mills scheduled to begin operation in western Virginia and West Virginia in the late 1990s or early 21st century illustrate this trend.

The recent pace of mechanization in paper and allied products has been even more rapid than in the lumber and wood products industry. New capital investments have increased by 250 percent in real terms and the value of shipments has doubled while employment has decreased to two-thirds of its 1972 level. Labor productivity has increased by 55 percent in real value per unit of cost. Meanwhile, this industry, like plywood and structural members, makes increasing use of hardwoods and the less utilized upland forest resource.

This long period of increasing capital investment and mechanization means that the wood processing sector's investment is now concentrated in its plant and equipment, and the return on this capital has become a crucial indicator of industry success. The high fixed costs and low variable costs associated with operating this capital, particularly for pulp and paper operations, place a premium on uninterrupted production. Therefore, we expect the wood processing industry in general, and pulp and paper operations in particular, to have an incentive to maintain limited forest resources under their own control as a guarantor of uninterrupted production for their mills.

Indeed, the industry does own forestland and the industry has been at the forefront in introducing improvements in forest growth and yield on its lands. It introduced the

first nurseries in the 1960s to grow the improved seedlings identified with the Fourth Forest. Some firms began participating in university research cooperatives at about the same time. Certain of these firms, and others as well, began their own independent forest management research programs. More recently, a few industry-owned fiber farms have begun to appear. These incorporate fertilization and irrigation into their management regimes in order to improve further on fast growth for high yields of uniform fiber.

Nevertheless, forest research expenditures and forest plantations remain a very small part of the industry's total financial investment and harvests from the industry's plantations are only sufficient to insure an uninterrupted flow of fiber in the most competitive times.[4] Only 45 percent of the industry's lands are in forest plantations, and the total of all industry lands is less than twenty percent of the total southern forest. Two-thirds of all timber harvested in the US South still originates from non-industrial private forestlands, approximately ninety percent of which are still managed extensively if at all.[5] These non-industrial private forests are at an economic frontier in the sense that the financial return on many of them is close to zero. These lands seldom have higher-valued competitive uses.

Clearly, the economic incentives for intensive forest management are not overwhelming—even in this very productive and technologically advanced region. Forestry has prospered in the US South, even as the geographic locus of harvests has shifted inland and upland with time. Two competing sources of fiber, debris from logging and processing and fifty million hectares of hardwood and mixed pine-hardwood forest, including nearly thirty million hectares of unmanaged and lower-valued upland hardwoods, continue to offer inexpensive alternatives to the higher cost fiber from more intensively managed pine plantations. Pulpmills have additional sources of fiber in the sawmill waste, recycled paper, old corrugated paper board, and other materials that provide about half of their raw material input. The South's largely unmanaged non-industrial forests and these substitute sources of fiber satisfy the vast majority of the southern industry's demand for raw material even today, and they are the reason that forest management itself has not become a more widespread and more intensive activity.

The Eastern Amazon

The development of the forest industry in Finland, in southern Ontario and Quebec in Canada, and in other developed economies as well has followed a general pattern similar to that of the US South. The state of Para in Brazil's eastern Amazon provides an alternative example. Brazil is the world's sixth largest exporter of sawn hardwood and half of the registered wood processing facilities in Brazil are in Para. The development of the forest industry in this region is more recent and it has not progressed

[4] In 1981, research expenditures as a share of total revenues were smaller in the forest products industries than in ten of fourteen other industries. Only food, textiles, petroleum and primary metals ranked lower. The shares for some of the remaining industries were more than ten times greater than the share for the forest products industries (Seldon 1985).

[5] Alig *et al.* (2001) project southern forest land use for the next twenty years. They foresee no change in these conditions over this period.

as far as in North America and Western Europe. Nevertheless, there are similarities. Stone (1997, 1997, 1998) traced the development of this region with a comparison of three milling centers; the municipalities of Tailandia, Breves, and Paragominas; that describe a continuum of access to the forest frontier.

Until the early 1980s, logging in the eastern Amazon was limited to fluvial areas and a few high-valued species. The history of the forest industry since then is one continued extraction from the natural forest (comparable to the US South's First Forest), although some natural regrowth comparable to the South's Second Forest has occurred in a few of the previously cutover lands. Forestry in the region has yet to attain the stage where resource scarcity and higher prices induce significant investment in managed forests.

The region developed rapidly because it has good access to port facilities in the capital city of Belem and good overland connections with the population centers in the south of Brazil via the Belem-Brasilia highway. The number of mills in the region expanded rapidly to over 1,500 officially registered mills in 1995, plus numerous small and mobile mills in the informal sector.

The logging and wood processing industries have become larger and increasingly capital intensive with time, and also with decreasing access to the forest frontier, and they demonstrate an increasing degree of vertical integration. Both logging operations and wood processing facilities employ a range of technologies—from rudimentary chainsaws to expensive bulldozers and mechanized skidders and loaders for logging, and from a single circular saw to sawmills with multiple lines of band saws. Sawmills comprise the great majority of wood processing establishments in the region, but there are a few plymills and veneer factories, some with multiple lathes, particularly in the more developed municipality of Paragominas.

Tailandia: Tailandia is the newest and least developed of the three municipalities. In the 1990s Tailandia was an isolated sawmill center approximately 200 km from the provincial capital of Belem. It had neither electricity, decent paved roads, nor inexpensive water transportation, but it did have thirty sawmills and two veneer operations and these supported numerous loggers.

Timber harvests around Tailandia were characterized by very selective logging. Loggers typically removed the best trees among fewer than twenty high-valued species in densities ranging from 14 to 19 m^3/ha. Timber removals comprised only eight percent of the forest canopy, and about 88 percent of the original forest remained standing after the harvest operation was complete. The common harvest technology was simple, involving only a chainsaw for felling and for opening a path for the logging truck, and a hand winch for loading. The technical efficiency of this operation was low. It left twice as much damaged wood in the forest as it removed and shipped to the mill. The average logging team, composed of three men, loaded 1,500 m^3/yr at an operating cost of US\$6.35/m^3, and these unit-costs were even lower for the smallest operators.

By the mid-1990s, more firms were engaged in logging and wood processing, their operations were increasingly mechanized, and more of them were vertically integrated. Only 23% of all sawmills hired included their own logging operation in 1990. That number increased to 38% by `995, and two-thirds of large mills were vertically integrated in 1995. There are no data on the forest disturbance caused by logging in the mid-1990s, but loggers clearly removed a greater variety of species and greater volumes per unit of logged area. Capital investment in logging increased as most logging operations now included a US$70,000 bulldozer. Larger operators, on average, owned three bulldozers and two mechanical loaders. (The capital-labor ratio increased from less than 0.9 in 1990 to greater than 1.1 in 1995.) The average logging operation, now comprised of nine men, loaded 10,000 m^3/yr, at an operating cost of approximately US$7/$m^3$. Increased mechanization permitted increases in the harvest volume/unit-area and per unit of labor, and decreased the unit cost of production. Stumpage prices remained low—at about US$77/ha or US$2/m^3.

The capital investment in hauling also increased as most loggers had US$200,000 invested in trucks by 1995, and larger operators had more than US$350,000 in trucks and loading equipment. Large operators were much more capital intensive than small operators (capital-labor ratios of 4.1 and 2.7, respectively). The average hauling distance in 1995 from the harvest site to Tailandia was 40 km. The unit transportation costs were low but the cost per kilometer was high (US$0.17/$m^3$/km), reflecting the low quality of the roads and the limited easy commercial access to the forest.

Small operators with a single band saw dominated Tailandia's wood processing enterprises in 1990 and they were still dominant in 1995. (The number of less efficient, but more mobile, circular saws declined between 1990 and 1995.) The smaller operators tended to be family enterprises with one or, occasionally, two production lines. Larger mills simply added a production line—without changing the production process. In 1990 about one-quarter of all mills were vertically integrated to include their own logging and hauling operations. The others purchased delivered logs from independent loggers. By 1995, almost half of the small mills (one saw) and more than half of the larger mills (multiple saws) were vertically integrated to include logging and hauling operations. In 1990, the average mill produced 3,000 to 4,000 m^3 of rough cut lumber annually. By 1995, the average mill in produced 5,000 m^3 annually at an average cost of about US$28/$m^3$ of sawnwood.

Breves: Breves is in the Amazon River delta, accessible only by water and air. Commercial electricity was unavailable in the 1990s. Highly selective logging had been conducted in the general area for over 300 years and numerous mills were still operating when Stone conducted his research. The slow pace of water transportation limited him to a sample of 24 mills, including one plymill and one veneer operation.

Logging around Breves has been associated with commercially mature and accessible *virola* (*Virola surinamensis* Warb.) timber, and recent changes in the industry are associated with its increasing scarcity. Traditionally, *virola* was manually felled along the estuaries and hauled to the river banks, where its low density allowed it to be

floated to the mill. Harvest costs were low and the harvest activity itself was very selective. The remaining forest was left largely undisturbed after the removal of mature *virola* timber.

More recently, as the inventory of mature *virola* has declined, loggers and mills have begun to exploit the tropical hardwoods growing further inland. The capital equipment required for these operations is much greater. Hardwood logging in Breves is similar to mechanized logging in Tailandia, and the logging costs per m^3 are roughly comparable (capital-labor ratios for logging range a little higher in Breves). Stumpage prices and hauling costs, however, are much lower in Breves. Hardwood stumpage prices in the mid-1990s were about US$15/ha, or well under US$1/m^3. These low prices could reflect market power and lack of competition for the small number of large operators who can afford the expensive capital equipment that permits their access to the inland hardwoods. Alternatively, it may reflect an activity that only occurs near the geographic limit of profitable timber harvests. The latter may be a more accurate explanation because the final unit processing costs (including all raw materials) for sawmills in Breves are only marginally less than those for Tailandia and Paragominas.

Hauling is the most capital intensive activity in this forest industry, but river borne transportation diminishes this considerably for Breves, from capital-labor ratios of 2.7 or greater for Tailandia to ratios of 0.4 for shipment of *virola* by raft and 1.3 shipment of hardwoods by barge. (The inland hardwoods are too heavy to float.) Barges represent a large capital investment of more than US$1.7 million, twelve times the investment in a diesel powered boat for those who tow rafts of *virola*. However, barge transportation reduces shipment costs to the very low level of US$0.07/$m^3$/km. As a result, mills in Breves can afford to bring logs from 73 km on average and from as far as 234 km.

Small family-run operations with single band saws and 3-4 employees comprised about half of all processing enterprises in Breves in 1990. These establishments averaged less than 1,000 m^3 of rough cut sawnwood per year. Their share of all wood processing enterprises remained approximately unchanged in 1995 but the scale of local operations became increasingly divergent. Large firms with multiple product lines produced 4-7,000 m^3 of sawnwood per line per year. All four large sawmills had their own loading docks for ocean-going vessels and two of them were vertically integrated as well, possessing the capital equipment for inland hardwood logging. These two ran as many as four lines of band saws and they were horizontally integrated with veneer and plymills. Stone speculated that it was this logging capital that provided them the cost advantage to build their larger processing capacities. The average production cost for the larger sawmills was US$27.47/$m^3$ of sawnwood. The average production costs for the smaller sawmills was a little less and the production costs of both large and small sawmills were a little less than those for comparably sized mills in Tailandia.

Stone speculated that the greater heterogeneity observed in the industry in Breves was due to the transition from *virola* to inland hardwoods and the returns to scale that a few firms with greater access to financial capital obtained when they invested in mechanized logging and barges for the water-borne transportation of denser hardwood

logs. The mobility of the smaller sawmills and, as family operations, their ability to avoid high labor taxes, continued to provide them an advantage in harvesting the small remaining pockets of *virola*.

Paragominas: Paragominas is the most accessible and most developed of the three municipalities. Its good infrastructure includes paved roads and commercial electricity. Over 230 registered wood processing firms operated in and around Paragominas in 1995. Stone reported on a scientifically random sample of 35 of them, including 20 small mills operating band saws, seven sawmills operating multiple production lines, four plymills and four veneer factories.

Logging operations were much more mechanized in Paragominas than either Tailandia or Breves. The investment in capital equipment by small firms was 2 ½ times greater than in Tailandia and eight times greater than in Breves. Larger firms invested half again as much as their counterparts in Tailandia and almost as much as those that operated inland hardwood log operations in Breves.[6] Three-fifths of all firms were vertically integrated into both logging and wood processing in 1990. Four-fifths were vertically integrated by 1995, and the value of capital equipment used in logging had increased further. Most of the lands around Paragominas had previously been logged selectively. Therefore, fewer high-valued trees and species remained. The greater mechanization of the Paragominas firms allowed them to overcome this disadvantage by profitably harvesting greater volumes per hectare—on average 38 m^3 from over 90 different species even in 1990—at unit costs that were less than those for the other two municipalities, at least for larger operators. Greater harvest volumes meant that less than half as much volume (<60m^3/ha) was left standing after the harvest activity was complete. Nevertheless, the technologically more advanced equipment in use in 1995 also reduced the environmental damage due to logging at each logging site.

The greater harvest volumes of Paragominas' logging firms also helped them recover from higher stumpage prices. The era of cheap raw material is over for Paragominas. Stumpage prices in 1995 averaged US$183/ha, or nearly $US4.50/$m^3$. The high price was partly explained by increasing scarcity and partly by the better defined and more stable property rights further from the frontier. (Better defined property rights mean that loggers invest less in negotiating harvest rights and some of the savings transfers to higher stumpage prices for the landowners.)

Capital costs for log shipment stand out in Paragominas as they did in Tailandia and Breves. The investment in logging trucks by the average firm in almost doubled from 1990 with the larger capacity trucks in use by 1995. This investment was larger than in Tailandia for both large and small firms in both 1990 and 1995. Delivered log prices were higher in Paragominas than in the other municipalities and they were higher in 1995 than in 1990 for all grades. Both of these observations follow our expectations

[6] Even as the additional capital equipment raised the capital-labor ratio for logging operations in Paragominas, unit capital costs for logging were closer to the higher costs experience of Breves than to the lower cost experience of Tailandia. Unit labor costs in Paragominas were similar to those for the other municipalities.

because hauling distances are greater in Paragominas (94 km on average) and because smaller operators regularly close their local operations and relocate closer to the frontier where they are more competitive. Unit hauling costs were about 50 percent greater in Paragominas than in Tailandia, but unit costs per km were lower in Paragominas (US$0.10)—due to better roads and greater distances over which to average fixed costs.[7]

Small sawmills comprised about half of all wood processing operations in Paragominas—as they did in Tailandia and Breves—and their annual production levels were similar. However, none of Paragominas' sawmills employed the less efficient but more mobile circular saws. Some small firms had consolidated operations between 1990 and 1995. Others had departed from Paragominas for regions closer to the frontier. Those small firms that remained tended to operate with highly depreciated equipment.

Larger mills also responded to the increasing competition and increasing costs away from the frontier. One-fourth of the larger mills had established satellite sawmills closer to the frontier and some firms with higher fixed costs were investigating the potential of plantation forestry.

The annual output rate per production line remained comparable to that in the other municipalities, but Paragominas had more large sawmills with multiple production lines and these large mills were responsible for a larger share of total production in Paragominas. Sawmill processing costs in the neighborhood of US$32/$m^3$ were only marginally larger than those for sawmills in Tailandia, but about 25 percent greater than for Breves. Four plymills and four veneer factories also operated in Paragominas. These more technologically advanced operations represented capital investments of nearly US$2 million apiece. They tend to operate multiple shifts and they produced forty percent of the municipality's final physical output. Finally, Paragominas also supported two export houses which do not process logs. They purchase export grade sawnwood for kiln drying, planning and packaging. The export houses represent an investment of more than US$0.5 million apiece. Gross revenues from their combined production exceeded US$7 million annually.

Summary Observations: Table 1 summarizes many of Stone's observations. The pattern of growth traced from less developed Tailandia to Breves to more developed Paragominas is general for the forest industry, with the caveat that river transportation at Breves adds another element.

It is clear that delivered log prices increase with distance, and they also increase over time as logging depletes the best timber at the frontier. (Stumpage prices decrease with average distance in this example, but stumpage prices are not a good measure because they do not represent uniform market points. Stumpage prices are an average of high prices for timber in more accessible locations nearer the mill and low prices in more poorly roaded, less accessible, locations closer to the frontier itself. Therefore, there is an undetermined element of transportation implicit in each stumpage price. Furthermore,

[7] Unit hauling costs were also declining in Paragominas, from US$0.20 in 1990 to US$0.10 in 1995. (Stone didn't provide these costs for Tailandia and Breves in 1990.)

each individual observation on stumpage price includes its own premium for more, or less, secure property rights. Lands with more secure rights bring higher stumpage prices. Lands with less secure rights bring lower prices but often require an additional fee for negotiating the rights. Delivered log prices are more useful for our comparisons because they do not hide these differences.)

Delivered prices increase as the frontier closes. The industry responds by substituting lower-valued species and by increasing the harvested volumes of smaller trees of higher-valued species. The industry also consolidates into the larger firms that can harvest and process the larger volumes. With larger volumes, opportunities to specialize arise at all levels of industry organization.

Larger, more specialized, firms require greater levels of capital investment in equipment that is suitable to the new task. Capital intensity increases and the return on capital becomes more important. More permanent factories operating multiple shifts become the norm and a regular supply of raw material to fuel the entire process becomes crucial. (Therefore some larger mills in Paragominas are considering investments in plantations to insure their own raw material supply.) Greater capital intensity and more specialized equipment probably require better skilled labor as well—although Stone's observations are not as clear on this.

Meanwhile, small and mobile firms with less specialized capital continue to operate near the frontier. Their size and mobility provide an advantage where there are small pockets of less accessible timber. The return on capital is not as important to them as it is for larger, more capital intensive firms. The smaller operations can be opportunistic, following the resource where they find it and taking advantage of good market conditions when they occur. The return on labor is relatively more important to these operations, but they are often family enterprises and some family members often have other employment opportunities.

These patterns are generally similar to those for the US South and we might anticipate that they are general for forestry and the forest industry almost anywhere. They show that the pattern of development may be gradual, as it has been for the US South, or rapid, as it has been for Brazil's eastern Amazon. It is also similar for developed and developing regions and countries. However, the pattern is not complete. Neither of the two general examples to which we have referred provides detail on the labor used in forestry operations. In fact, the forestry literature is not strong on this point. However, an example from the bamboo sector in China provides some insight.

The Bamboo Sector in China

The experience of China's bamboo sector is relevant for us because timber and bamboo share the same factors of production production and their markets also share many similarities. On the supply side, they compete for similar land, labor, and capital resources, either for extraction from the natural forest or for farm management and growth. On the demand side, bamboo and timber compete in many of the same

markets—panels, flooring, plywood, fiber for paper, and even some construction framing materials. China's logging ban, imposed in 1998, provided evidence of the similarities between timber and bamboo. The demand for timber substitutes increased immediately. Bamboo prices and production rates demonstrated its substitution. Bamboo prices increased almost 10 % in 1999 and new bamboo plantations increased by 17 %. China's State Forestry Administration expects that bamboo will substitute for 29 million m^3 of wood by 2010 (CFIC 1998).

Ruiz Perez *et al*. (1996, 1999, 2001, 2001) examined the growth and development of China's bamboo industry through the 1990s with particular emphasis on the effect on household incomes. They relied on surveys of individual farm households and industrial firm managers, of key informants, on farm records, and on county price and production records. They focused, first, on Anji County in Zhejiang Province and, subsequently, reviewed the experience in five additional counties. Zhejiang is an economically dynamic coastal province near Shanghai. It is one of four provinces that account for two-thirds of China's bamboo production. The province, like all of China, has developed rapidly in response to China's reforms of the last 25 years. Coastal provinces such as Zhejiang began developing earlier and more rapidly than some others and Zjejiang's bamboo sector developed particularly rapidly.

The other five counties in the Ruiz Perez *et al*. analysis follow an east-west grid inland to about 1700 km from Anji. Production increased in all six counties, and key informants in all six identified a stable policy environment a precondition for the increase.[8] Productivity per land unit was greater in the eastern counties and the richest county, Anji, experienced the highest average productivity. The poorest county, Pingjiang, experienced the lowest—less than one-third of that in Anji. In general, farm households in all income classes in all counties benefited, but middle and higher income households benefited most and improved off-farm labor opportunity was the source of the greatest improvement.

Anji's Experience: In 1975, 51,000 ha in Anji were managed for bamboo, 99% of it in farm collectives. Bamboo was sold through a state marketing collective at fixed procurement prices. Household Responsibility contracts, introduced in Anji in 1983-1984, brought an immediate change in bamboo production. Individual households managed 40,000 ha of bamboo by 1984 and total output in the county increased 63% by 1988—with little increase in the land area devoted to bamboo. The government first revised, then eliminated, the procurement price system in 1985. By this time, individual farmers were responsible for 91% of total county production. Prices and production continued to increase through the 1990s. Altogether, prices rose almost 300% (in constant terms) from the late 1970s. Production rose more than 90% by 1998.

[8] Policies designed to identify property rights had changed four times over a period of thirty years and farmers in China are particularly aware of its effect on investment and management. Any longer term investment, including both forestry and bamboo, is difficult to justify under this kind of uncertainty. The new Household Responsibility contracts for agricultural land, beginning in 1978, were the first step in China's modern reforms. Many of these were renewed in the mid-1990s and farmers were particularly alert to the possibility of another policy change before they were renewed (Hyde *et al.* 2003).

In 1978, 96% of Anji's production was sold in unprocessed form and shipped out of the county. The nineteen local bamboo processing establishments employed only 460 workers and produced 960,000 yuan (US$670,000) worth of finished goods. Various marketing reforms created new opportunity for expansion and, by 1998, Anji had 1,182 processing establishments employing 18,914 workers. Annual production exceeded 875 million yuan (US$105 million) in value.

Growth in the processing sector put upward pressure on the prices of the primary bamboo resource. In response, the marketing system grew more specialized until more than 200 bamboo traders were operating in Anji in the mid-1990s. Meanwhile, some processing establishments, concerned for the supply of their own raw material, began arranging production agreements with farmers at prices agreed upon before the harvest period. Some agreements included cash advances. Eventually, the processing sector began importing raw material from other counties.

Despite the impressive growth and diversification, there has been little expansion in the number of farm households or the land area devoted to primary production. Approximately 120,000 farm households remain the foundation of the industry.

Ruiz Perez *et al.* examined a scientific sample of 200 farm households in 1994-1995 and compared their evidence with evidence from 1989-1990. They divided households into five income classes for the sake of comparing the sources of income and income growth. Average incomes rose 6.7% in real terms over the five-year period but bamboo remained as a fairly constant 24-25% share of income in both years. The contribution of agriculture to household income also relatively constant, but much larger share, across all income classes. Therefore, Ruiz Perez *et al*. concluded that agriculture provided a common economic foundation for all households.

Income from bamboo increased for all income classes, and it was an increasingly important source of on-farm income for higher income classes. However, off-farm employment (some of it in bamboo processing establishments) was the largest source of income difference between different classes of households and it was especially important for households in the highest income class.[9] Figures 1 and 2 show the relative importance of income from bamboo to each income class in the two years. Both figures display the convex shape that means that bamboo was a relatively more important source of income for middle income groups. It was the source of 30% of household income for the second and third quintiles of households, but barely 20% of income for the extreme first and fifth quintiles.

[9] Others (e.g., Scherr 1998) have observed that forestry is a convenient land use for those with off-farm employment. Forestry is less labor-intensive than most agricultural crops or livestock and the timing of forest management activities is more flexible than the strict seasonal requirements of many agricultural activities. We can presume that bamboo shares these characteristics with forestry. They permit those with off-farm employment to continue their employment without sacrificing the productivity of their land.

Table 2 shows the results of a regression assessing the sources of differences in per capita income levels in the two years. Male labor, arable land, bamboo land, and off-farm employment have significant income increasing effects. The income elasticities of bamboo land and off-farm labor are 0.32 and 0.48, respectively. Once more, it is clear that improvements in bamboo production opportunities benefited household incomes, but additional off-farm labor opportunity was the crucial ingredient for the income growth that occurred between 1989-1990 and 1994-1995.

The Multi-County Comparison: Between 1980 and 1998, the number of farmers growing bamboo in the broader six-county sample increased 91% and the share of all farmers growing bamboo increased from 19% to 26%. The processing sector expanded in five of the six counties, doubling the share of primary processing conducted in the counties and offering better markets for farmers who increased their bamboo production, and more opportunities for both household-based pre-processing for the industry as well as for off-farm employment in the industry itself.

The profiles of the processing sector differed across the counties. Three of the counties are illustrative:

- Muchuan in the west is not as diverse, either generally or in its bamboo industry. Papermaking accounted for 99% of all bamboo processing and 36% of county output from all industrial sources. The high profit rate (24%) in the industry indicates a growing industry that will probably continue to expand. The industry clearly is a development leader for this county.

- Taojing is geographically more central and industrially more diverse. Bamboo processing accounted for 12% of Taojing's industrial output in 1998. The industry's 19% profit rate indicates an industry that is still growing. Taojing has the lowest wage and per capita incomes of the six counties and the greatest contribution of the primary sector to county GDP. The processing sector is taking advantage of low wages to expand more rapidly than in the other counties.

- Longyou is the most developed of the six counties. Per capita income is double that in the second most developed county and Longyou's industry is the most diverse. Bamboo processing (for papermaking, plywood, and various other products) is only 7% of total industrial output. The bamboo industry grew over the twenty-year period but its 8% profit rate now approximates that of other industries in the county. Therefore, bamboo processing no longer has a competitive edge and it is no longer a leading source of county growth.

The profiles of farm incomes, wages, and employment also differ across the counties. Farm incomes are growing but the disparity in farm incomes is also growing—within counties and across counties. Bamboo production and pre-processing conducted in the household improved household income in all counties. Longyou's farm households recorded the largest income shares from bamboo. They also reported the widest spread of income—in general and from bamboo—and they attained the highest

income levels for farmers in any of the six counties. Their farm production was more specialized and they experienced more off-farm employment—as might be anticipated in the most developed and diversified country. Muchuan's farmers received the most rapid income gains in more recent years—probably as a result of rapid growth and increasing demand in Muchuan's bamboo processing industry. In general, and across all counties, poor farmers benefited with increasing incomes from bamboo, but they benefited proportionally less than farmers in higher income classes.

General Observations and Further Insights

The pattern of development of the forest products industry is similar—whether traced over time in the US South or across space as in eastern Brazil and China. In fact, the more limited of discussion of the geographic dispersion in the US South and more limited intertemporal discussions of Brazil and China also follow the pattern. Finally, the pattern is similar whether we follow the full forest and wood products industry—as in the US South—or a more limited portion of the industry—as in the limited processing observed to date in eastern Brazil or the more specialized case of the bamboo industry in China.

That is, agriculture opens the new frontier. Logging follows and eventually disperses across the boundary of the frontier and farther into the original natural forest. The initial wood processing operations always set up near the frontier because the costs of logging and hauling are such a large share of the delivered cost of the basic woody raw material. Eventually, as logging penetrates farther into the frontier, rising logging and shipment costs force the mills to adjust. Some small and rudimentary mills are mobile and they move closer to the resource. Others remain in their former locations, but increase their capital intensity.

Marketing specialists—such as the consultants who advise on the sale of non-industrial private timber in the US South or the purchasing agents in China—begin to appear, and the ownership rights to forest properties also become clearer—as in Brazil.

The more capital intensive operations, both logging and milling, cover their greater costs by harvesting larger quantities and they begin to make use of smaller and lower quality logs. Some develop their own log yards and establish secondary markets for the size classes and species that do not match the requirements of the own mills.

Eventually, some vertically integrated operations consider operating their own managed natural forests and even their own forest plantations. This happens as the reliable supply of woody raw material becomes a concern for the most capital intensive wood processing operations. At about the same time, the cost of harvesting and transporting logs from the frontier begins to approximate the combined costs of growing, logging and transporting logs grown nearer to the mill and this, too, makes plantations more attractive.

Who benefits from forest development? Of course, those who have access to the large sources of capital necessary to establish the modern capital intensive wood processing facilities that appear later in this pattern of development benefit. But who else benefits?

The original workers in the new forest industry already live near the forest frontier. They are mostly local farmers and other agricultural seeking to supplement their income with part-time or seasonal employment. Some begin to operate their own rudimentary sawmills, but these also tend to use their mills to supplement household income as they too operate either seasonally or when market conditions are most favorable.

Eventually, as the wood processing industry develops, the employment opportunities expand for some. As logging itself expands farther into the forest frontier and away from the local agricultural communities, it becomes a full time occupation for some and employment in the mill in town becomes a full time occupation for others. Evidence **from Nepal (Bluffstone 19 ,** Amacher *et al*. 1999), India (Foster *et al*. 1997), Sri Lanka (Gunatilake 1998), Peru (Escobal and Aldana 2003) and VietNam (Tachibana *et al*. 2001) shows that those who become employed in the industry at this stage of its development generally were subsistence farmers who now place fewer demands of their own on the natural forest, and the forest environment may even benefit as a result.

As the industry continues its development, some small landowners begin to benefit from the sale of their own timber. Where the local institutions insure long term secure property rights, some of these small landowners find advantage to growing timber as a source of household income. Eventually, however, further development only occurs with greater capital intensity—in forest management, in logging operations, and in mill operation. More capital intensity means more specialized demands on labor and greater demand for skilled labor.

The security of property rights is a crucial characteristic of rural development. Any investment requires confidence that the expected future return from the investment will be the property of the investor. Longer term investments, such as those in trees, require confidence that the investment climate will remain reliable for a longer period—the period it takes for the trees to grow to a size that will yield marketable benefit to the investor.

Examples of the importance of secure tenure are numerous. China's modern market reforms began in 1978 with 25-year household contracts for agricultural land. Agricultural production grew as much as 8 1/2–fold in six years. Although other reforms had their beneficial effects as well, Lin (1992) showed that improved land tenure was responsible for the majority of the increase in production.

Chinese farmers were cautious. The rules for land tenure had changed four times in twenty years. Nevertheless, even with the uncertainty generated by this experience, some farmers planted trees and the resulting improvement in the agricultural environment

explained 10% of the growth in agricultural production over those first six years of reforms. Of course, the beneficial impact of these only increased as they matured beyond the young growth of their first six years or less (Yin and Newman 1997). Forest cover on China's former collective agricultural lands increased 60 % between 1978 and 1998 (Hyde *et al.* 2003).

A secure investment climate, however, requires more than reliable contracts for forestland. Argentina and the Philippines provide examples. Where the mountain passes between Argentina and Chile are low, Argentina experiences many of the same growing conditions as those that have made Chile's forest sector internationally well-known for its productivity. Yet Argentina has not shared the experience of high productivity. The difference is one of general economic conditions. Chile's economy has been stable for 25 years. Argentina has experienced wide fluctuations in inflation and unpredictable labor market that makes it difficult for landowners with trees to predict the profitability of their timber investments.

The Philippine Bureau of Forest Development (BFD) established a policy of land transfers to communities in 1995 supported by a US$40 million loan from the Asian Development Bank. However, various NGOs were concerned about the potential distribution of benefits from the transfers and the BFD was concerned that the communities would fail to follow its own perception of good forest management. Therefore, the BFD required each community to hire a forester, to report management plans to regional and central advisory committees for approval, and to return 44 percent of gross revenues from the community forests to a central account used to pay down the loan. These requirements were too severe and not one community in the entire country applied for the transfer of community forests until these requirements were withdrawn in 1997 (Hyde *et al*. 1997).

In sum, there seem to be opportunities for the poorest and for those with the least specialized skills at every stage in the industry's development. However, the simple presence of a forest stock is not a sufficient basis for development. The appropriate market conditions and land tenures must also be in place. Furthermore, where forestry can be a basis for development, the industry's development does not necessarily mean that those who benefit most will be the poorest. In fact, those who benefit most seem to be those who are more entrepreneurial and who have some technical skills—those who own sufficient amounts of land to be able to devote some of it to a long term investment like forestry and those who can develop the specialized skills required to operate modern logging equipment and milling machinery.

The Mekong Basin

What do these experiences with forest development suggest for the Mekong Basin? What characteristics of successful forest development can we observe in the Mekong Basin and where in the Basin do those characteristics take their most favorable form. What is this likely to mean for alleviating poverty in those most promising locations?

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Table 1: Characteristics of the Forest Products Industry in Three Municipalities in Brazil's Eastern Amazon[1]

Characteristic (average measures)	Tailandia		Breves		Paragominas	
	1990	1995	1990	1995	1990	1995
Stumpage price ($/ha)	-	77	-	15	-	183
($/m^3)		2		≈ 0		<4.50
Harvest volume (m^3/ha)	14-19		-	-	38	-
Log haul (km)	-	40	-	73	-	94
Delivered log price ($/m^3)	-	-	-	-	38	43
Unit costs of production ($/m^3)[2]						
logging	-	5.34 – 8.92	-	6.12 – 10.26	-	8.72 – 8.15
hauling	-	7.55 – 5.63	-	8.05 – 11.53	-	10.04 – 8.19
sawmill processing	-	27.95 – 32.07	-	22.96 – 27.47	-	31.83 – 33.24
Current value of capital investment[2]						
logging ($000)	<.84 -	69 – 288	< .84 -	22 – 518	-	168 – 409
hauling ($000)	-	97 – 186	-	99 – 715	-	227 – 376
wood processing facilities (no.)[3]						
small sawmills—circular saws	-	2	-	12	-	0
small sawmills—band saws	-	22	-	7	-	20
large sawmills	-	6	-	4	-	7
veneer and plywood operations	-	2	-	2	-	4

[1] Vacant cells indicate no information

[2] The first entrée is for small operators, the second is for large operators

[3] The sample for Tailandia is the full population. The sample for Breves includes all mills that were readily accessible. The sample for Paragominas is a scientifically random sample of the total population of 238 mills. Additional mills operated in the informal sector in all three municipalities.

Source: compiled from Stone (1997, 1998)

Figure 1: Relative Importance of Bamboo Income in Anji County—by Household Income Class, 1989-1990

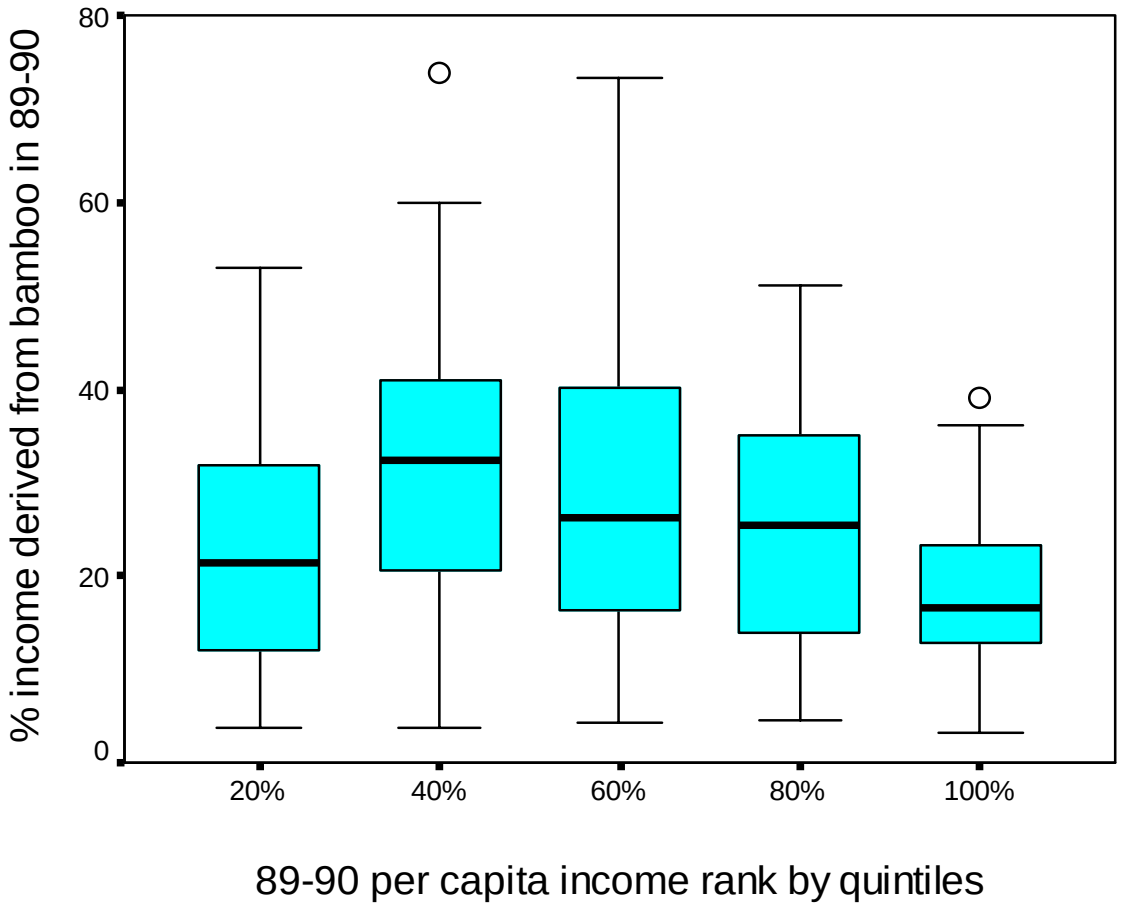

Figure 2: Relative Importance of Bamboo Income in Anji County—by Household Income Class, 1994-1995

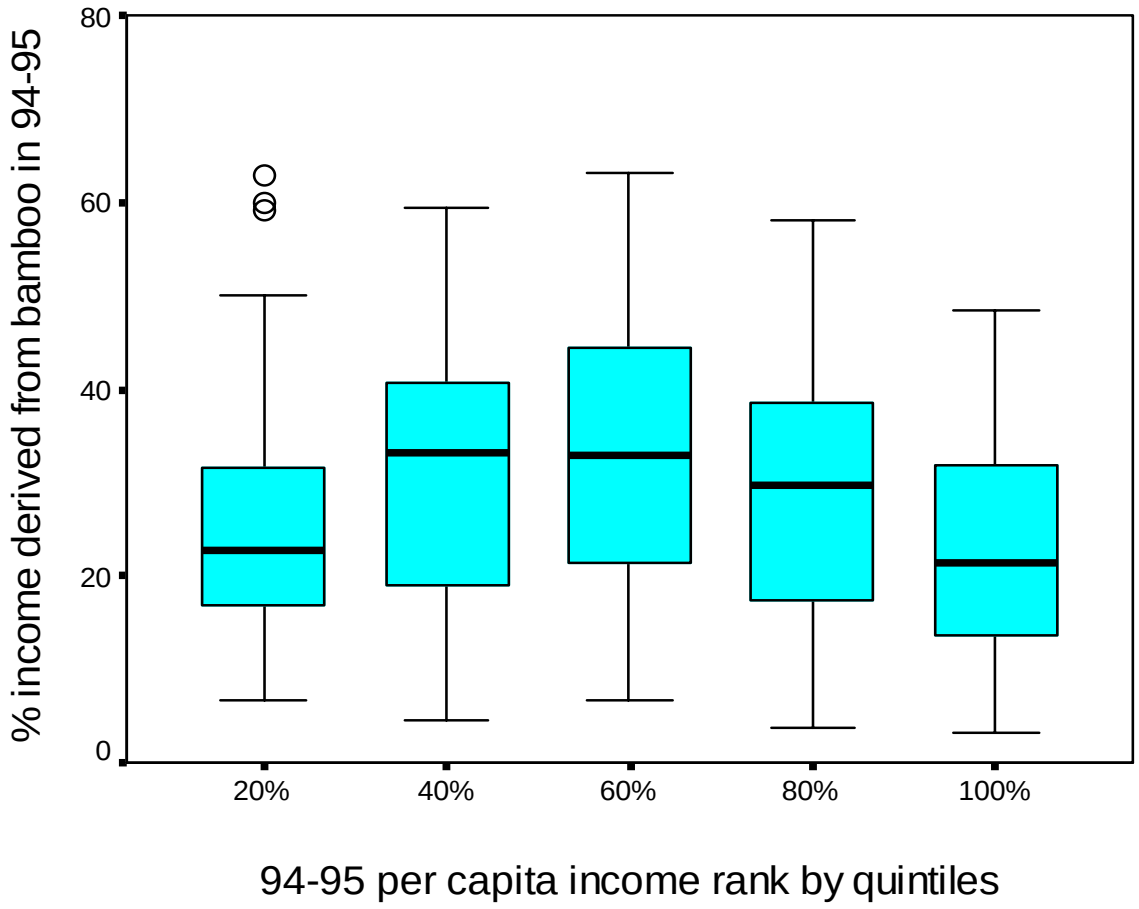

Table 2: Sources of Difference in Per Capita Farm Income in Anji County, 1989-1990 to 1994-1995.

Variable	*B-coefficient*	β-*coefficient*	*T-value*
Age, head of household (yrs)	–19.8	–0.127	–1.996
Family size	–297.8	–0.225	–3.198
Male/total labor ratio	1,361.6	0.152	2.244
Arable land	114.6	0.151	2.373
Bamboo land	53.9	0.390	5.997
Off-farm/total work ratio	855.2	0.157	2.420
Township	107.5	0.178	2.717
Constant	1,632.8		2.863

$R^2 = 0.341$	Adjusted $R^2 = 0.317$	$F = 14.178$ Probability $F < 0.0001$

Source: Ruiz Perez *et al.* (2003).