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EFFICIENCY AND EMPLOYMENT IN ECUADOR'S SAWNWOOD INDUSTRY

Jeffrey P. Prestemon

FPEI Working Paper No. 41

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Raleigh

1988

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ABSTRACT

In Ecuador, lumber and other sawnwood products are produced by chainsaw sawmill operators ("motosierristas") and small sawmills. Motosierristas and sawmills compete for timber and markets. This provides the rationale for comparing efficiencies and employment impacts of the two alternative technologies.

Sawmills exhibit higher factor productivities than motosierristas in the highlands and the coastal regions. Motosierristas in the highlands are more labor-intensive than sawmills, indicating a potential trade-off between employment and efficiency in that region. Comprehensive measures of efficiency indicate that sawmills are more efficient than motosierristas, except in Amazonia. This study was unable to identify the potential causes for variations in efficiency.

If high factor efficiency in sawnwood production is the goal for the forest-based sector, then infrastructural development should be a high priority in Amazonia. On the other hand, if employment promotion is indicated, then motosierristas should be the technology of choice. If decision-makers want to both improve efficiency and promote employment, then several actions could be taken, including: (1) further research into the underlying determinants of technical efficiency; (2) identification and promotion of firms possessing such characteristics; (3) road construction in areas where sawmills are presently

inefficient (including Amazonia); (4) investigation into conversion efficiency-enhancing technologies for motosierristas; and (5) definition of other policies designed to eliminate inefficient firms while encouraging efficient ones.

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Eficiencia y empleo en la producción de la madera aserrada en Ecuador.

En Ecuador se produce la gran mayoría de la madera aserrada por aserraderos tradicionales y por motosierra. Aserraderos y motosierristas compiten en la compra de madera en pie y en la venta del producto terminado. Por lo tanto, se puede comparar eficiencias y el impacto del empleo de las dos tecnologías alternas.

Aserraderos tradicionales demuestran mayor eficiencia en el uso de los factores de producción en las regiones de la sierra y la costa. Motosierristas en la sierra son más intensivos en el uso de mano de obra que los aserraderos, lo cual indica que existen dos políticas alternas en la región: o incrementar la eficiencia a través de la producción con aserraderos, o promover el empleo a través de la producción con motosierra. Las medidas comprensivas indican que la producción de madera aserrada con aserradero es más eficiente que la producción con motosierra, excepto en la región amazónica. Este estudio no pudo identificar las causas potenciales por la variación en eficiencia.

Si la meta del sector forestal es aumentar la eficiencia en la producción de madera aserrada, el desarrollo de la infraestructura debería ser una alta prioridad en la región amazónica del país. En cambio, si lo importante es promover el empleo rural, entonces la mejor tecnología es la producción con motosierra. Finalmente, si los que toman decisiones quisieran

incrementar la eficiencia y promover el empleo, varias acciones se podrían tomar, incluyendo: (1) investigación adicional sobre las características de la producción con alta eficiencia técnica; (2) identificación y promoción de las empresas que posean tales características; (3) construcción de carreteras y otras vías de acceso al bosque donde aún quedan hoy aserraderos tradicionales menos eficientes (incluyendo en la región amazónica); (4) investigación sobre tecnologías para aumentar la eficiencia de conversión de la madera en troza al producto terminado empleando la motosierra; y (5) definición de otras políticas que sean diseñadas para desincentivar empresas no eficientes y promover las empresas más eficientes.

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INTRODUCTION

The field of rural development demonstrates much interest in the promotion of small scale enterprises (SSEs) as a means of increasing employment and incomes of the poor in Less Developed Countries (LDCs) (Little 1987). The context includes issues related to: (1) choice of optimal firm size; (2) choice of optimal technology; and (3) identification of strategies and policies to help the most efficient firms generate employment and contribute to economic growth.

Small firms are seen by some as appropriate to the developing country's situation, large firms having failed to solve the problems of underemployment and poverty (Liedholm and Mead 1987). The claim is that these SSEs are desirable for those countries because they employ a higher proportion of labor, utilize a higher proportion of unskilled labor, and require lower levels of capital per unit of output than large firms. These proportions accurately reflect a developing economy's labor abundance and capital scarcity (Little et al. 1987).

The issues of employment and efficiency are important in Ecuador's sawnwood industry. The industry is divided into two subindustries according to two technologies: (1) small fixed sawmills, using motor-driven circular saws with hand-fashioned blades; and (2) chainsaw operations in the forest, where chainsaw operators ("motosierristas") cut

boards from logs at the stump.

The view of many in Ecuador is that: (1) chainsaw sawnwood production is wasteful of the forest resource, and (2) motosierristas compete in the raw material and product markets with more efficient small-scale sawmills. If these two arguments are indeed true, then motosierrista activity should be discouraged.

The goal of this research is to investigate the accuracy of the preceding view by:

1. determining which subindustry, motosierristas or small sawmills, better promotes employment;
2. determining which subindustry is more efficient in using production inputs; and
3. making policy recommendations which could help Ecuador meet its employment and income objectives for the forest-based sector.

ECUADOR'S SAWNWOOD INDUSTRY

Survey of firms

A nationwide survey of forest industry firms was carried out in 1987 (see Appendix A). A quota sampling technique was employed to select firms for interviews (Sudman 1976). The number of firms sampled per locale was proportional to the locality's estimated level of forest industry activity. Information was gathered on roundwood consumption, labor and capital inputs, other inputs to

production, and the quantity and mix of sawnwood outputs. Over 180 sawnwood producers were interviewed. Every province (except the Galápagos) was sampled. In addition, a field count was performed to estimate the population of sawmills and other forest products firms. The field count was used to estimate national production, consumption, and employment levels.

The number of motosierristas was estimated indirectly by asking secondary processors the percentage of sawnwood they buy from motosierristas. That percentage was then used to calculate the national total volume of sawnwood deriving from motosierristas. Based on the annual sawnwood volume produced by the average motosierrista, the total number of motosierristas was calculated.

Industry size, composition, and employment

Data from the nationwide survey indicate at least 4500 motosierristas and 293 small sawmills in Ecuador (see Table 1 and Appendix A for an explanation of how these estimates were made). These producers supply both final users and secondary manufacturers. Each motosierrista consumes a mean of 560 m^3 of roundwood, producing about 225 m^3 of sawnwood per year (Guerrón 1988a). Each small sawmill consumes a mean of 3,300 m^3 of roundwood, producing over 2,500 m^3 of sawnwood per year.

1. Summary of investment, roundwood inputs, sawnwood outputs, and employment in Ecuador's sawnwood industry, by technology and region (1987).

	Region	Technology: Motosierrista		Technology: Small Sawmill	
No. Firms[1]	Coast	1654		130	
	Amazonia	1308		16	
	Highlands	1538		147	
	All Regions	4500		293	
Capital Investment[2] (1000 sucres per year)	Coast	124		6166	
	Amazonia	84		265	
	Highlands	60*		465*	
	All Regions	84		2845	
Roundwood Input[3] (m^3/year)	Coast	563	(930)[4]	4830	(628)
	Amazonia	563	(736)	1227	(20)
	Highlands	563	(865)	2440	(359)
	All Regions	563	(2531)	3329	(1007)
Lumber Output[3] (m^3/year)	Coast	225	(372)	4404	(572)
	Amazonia	225	(294)	506	(8)
	Highlands	225	(346)	1233	(181)
	All Regions	225	(1012)	2538	(761)
Employment (Hired) (man-years per year)	Coast	0.49*	(808)	3.77*	(490)
	Amazonia	0.74*	(966)	2.23*	(37)
	Highlands	0.62*	(951)	2.63*	(386)
	All Regions	0.61*	(2725)	3.08*	(903)
Employment (Unpaid family) (man-years per year)	Coast	0.98	(1616)	1.07	(170)
	Amazonia	1.50	(1962)	1.13	(23)
	Highlands	1.10	(1697)	1.31	(193)
	All Regions	1.17	(5275)	1.33	(386)

Notes:
1. See Appendix A for details on estimations.
2. Flow of capital services per year, evaluated at 7.5% real interest; not including the opportunity cost of inventory (see Appendix B for details).
3. All volumes for motosierristas are based on a substudy conducted by Guerrón (1988a), in which motosierristas consume approximately 3.75 meters of roundwood per day, produce approximately 1.5 cubic meters per day and work an average of 150 full days per year.
4. National totals in parentheses.

* Indicate significant differences between technologies, at the 95% level of confidence.

Nationally, motosierristas annually utilize over 2700 man-years of hired labor and nearly 5300 man-years of family labor. Neither of these values includes proprietary labor inputs. Annual capital costs per establishment average about 84,000 Sucres (US$ 335). Sawmills annually utilize over 900 man-years of hired labor and nearly 400 man-years of family labor. Annual capital costs per establishment are about 2,845,000 Sucres (US$ 11,400).

Table 1 also shows that motosierristas consume about 70 percent of all roundwood used for sawnwood, and that chainsaw sawnwood comprises approximately 57 percent of all sawnwood produced. Motosierristas are by far the dominant producers in Amazonia, probably because they require less infrastructure than sawmills in that less-developed region.

Technologies and markets

Do motosierristas and small sawmills supply the same markets? If each subindustry supplies a distinct market, the issue of which to promote becomes extremely complicated. The question of market overlap requires analysis of raw material sources and prices, product mix, and product destinations.

The average motosierrista works with one unpaid family member and one hired part-time worker. Typically, motosierristas work in private and government-owned land full-time for about seven months per year, usually during

the dry season. Forests are selectively cut for large, high-value trees. Logs are bucked and cut free-handed along an inkline into boards (normally measuring 5 X 25 X 260cm). The average motosierrista produces from 1.0 to 1.5m^3 of sawnwood per day, much of which contains warps, uneven dimensions and rough surfaces (Guerrón 1988a).

After cutting, sawnwood is transported by mule to the nearest road or to the motosierrista's home. It is subsequently sold to third parties or delivered to final users, such as local residents. Motosierristas are often the first producers of sawnwood in newly-settled regions.

Most motosierristas are self-employed. However, some work as contractors for sawnwood buyers and others as salvage cutters. The latter are contracted by ranchers who desire a cleared field for their cattle, and who want the valuable timber removed before final clearing.

The average sawmill proprietor works with one unpaid family member and three hired full-time workers. Unlike motosierristas, sawmills buy delivered logs and therefore require a harvesting infrastructure (i.e., roads, landings, skid trails, etc.). Logs derive from timber harvested at a higher volume per unit area than timber harvested by motosierristas (Montesdeoca 1987).

Table 2 gives the prices faced by firms for roundwood and sawnwood products. T-tests reveal that prices for roundwood and for products vary significantly between

subindustries. This is true nationally as well as within regions. Motosierristas pay significantly less for roundwood. This is an unsurprising finding, given that motosierristas purchase roundwood as stumpage, while small sawmills purchase delivered logs. Both subindustries incur motosierristas in the transport of sawnwood to the point of sale, and sawmills in the purchase price of delivered logs plus the delivery of sawnwood products.

Table 2. Prices of roundwood and sawnwood, and destination of final products for sawnwood producers in Ecuador, by subindustry and by region (1987).

	Region	Technology	
		Motosierrista	Small Sawmill
Roundwood Price[1] (sucres per m^3)	Coast	1025*	3113*
	Amazonia	698*	6746*
	Highlands	1160*	2986*
	All Regions	976*	3580*
Sawnwood Price[2] (sucres per m^3)	Coast	8258*	17588*
	Amazonia	8908	14584
	Highlands	7786	27164
	All Regions	8286*	21337*
Product Destination (%)			
Final Users	Coast	2.2	9.4
	Amazonia	6.6	45.5
	Highlands	18.1	45.2
	All Regions	9.0	16.7
Third Parties	Coast	97.8	90.6
	Amazonia	93.4	50.9
	Highlands	81.9	54.7
	All Regions	91.0	83.2
Internal Use	Coast	0.0	0.0
	Amazonia	0.0	3.5
	Highlands	0.0	***
	All Regions	0.0	***

Notes: 1. Prices differences between subindustries are slightly significant in the highlands (alpha = 0.102) and Amazonia (alpha = 0.078).

* Indicate significant differences between technologies, at the 95% level of confidence.

*** Less than one-tenth of one percent.

In terms of products, sawmills receive a significantly higher price per cubic meter than motosierristas in the coastal region. Price differences are only marginally significant in Amazonia (an alpha-level of 0.78) and the highlands (alpha=0.102).

Most sawnwood for both motosierristas and sawmills is sold to third parties. However, this varies by region. In the highlands, sawmills sell a large portion of their production (45.2 percent) to final users. Motosierristas, however, sell only 18.1 percent to final users. A possible explanation for this difference is that sawmills produce nearly all of the form-quality eucalyptus lumber. In the other two regions, both subindustries appear to sell approximately equal proportions of their products to third parties and final users.

Data presented in Tables 3 and 4 show that both subindustries utilize the same major tree species in production, and both produce many of the same sawnwood products. A substudy conducted concurrently with this survey revealed that motosierristas rarely perceive competition with sawmills as an important constraint (Prestemon 1987). This is not necessarily inconsistent with Tables 3 and 4, given that motosierristas often work in localities where sawmills are not active.

Table 3. Major timber species utilized by sawnwood producers in Ecuador, by subindustry (1987).

Motosierristas		Small Sawmills	
Species Name	% Freq.[1]	Species Name	% Freq.[1]
Cordia alliadora	9.8	Eucalyptus globulus	10.5
Cedrela rosei	6.9	Cordia alliadora	6.7
Nectandra spp.	5.1	Nectandra spp.	4.6
Eucalyptus globulus	3.9	Cedrela rosei	4.6
Tabebuia guayacan	3.1	Triplaris guayaquilensis	4.2
Dacryodes occidentalis	2.8	Nectandra pisi Miq., or Nectandra spp.	3.2
Hieronyma chocoensis		Brosimum utile	
Pouteria spp.		Himatanthus sucuuba	
Brosimum utile		Ceiba pentandra	
Platymiscium pinnatum		Pinus spp.	
Triplaris guayaquilensis		Otoba parvifolia	
Cedrelinga catenaeformis		Dacryodes occidentalis	
Carapa guianensis		Tabebuia guayacan	
Clarisia racemosa		Terminalia amazonia	
Virola surinamensis		Vismia spp.	
		Humiriastrum procerum	

Notes:
1. Percentage frequency of species mentioned as utilized in the subindustry. Species without percentages were less frequently mentioned.
2. Sources: AIMA 1987, Guerrón 1988b, Record and Hess 1949, and Woods 1949.

Table 4. Major products of sawnwood producers in Ecuador, by subindustry (1987).

Product	Dimensions[1] (cm)	Subindustry Motosierristas	Small Sawmills
		. . percent	frequency[4] . .
Tablon	4.5 x 25 x 240	[4]4	18
Tabla	2.5 x 25 x 240	30	40
Troza[2]	40 x 240	11	0
Doble Pieza	16 x 25 x 250	4.5	*
Vigas[3]	12 x 8	2	*
Piezas	8 x 25 x 250	2	3.5
Duelas	2 x 12 x 250	*	1

Notes:
1. Dimensions vary widely by region. In the highlands and Amazonia lumber is usually 230 cm to 250 cm in length; in the north coast, 420 cm.
2. Logs sold by motosierristas range in length from 230 cm in the highlands and Amazonia, to 420 cm in the north coast. Numbers given here are by average diameter and length.
3. Dimensions shown are width by thickness; sold in lineal units, usually 3 to 7 meters.
4. Percentages do not sum to 100, due to a large percentage of unclassified products in interviews.
5. Source: Guerrón 1988c.

* Asterisks represent less than one percent frequency.

In summary, prices for raw materials and products differ between subindustries. The subindustries differ by region in the quantities of wood sold to third parties and final users. Motosierristas perceive little competition from sawmills. However, on a national scale, both subindustries sell similar proportions of their output to third parties and final users. Moreover, wood species and products are similar. Thus, while each subindustry plays a key role in certain submarkets, there is sufficient market overlap to rationalize an evaluation of choice of technology.

ANALYTICAL FRAMEWORK FOR COMPARING TECHNOLOGIES

Measures of efficiency

Partial measures of efficiency relate output (value-added) to the quantity or value of one scarce production input. Capital intensity and factor productivities are the partial measures most commonly used to evaluate the efficiency of particular sizes of plants and production technologies. The most common factor productivities are the output to capital ratio (Q/K) and the output to labor ratio (Q/L) (or their inverses, K/Q and L/Q, respectively). Examination of these measures in combination can give an idea of a firm's or industry's production efficiency.

Comprehensive measures can be divided into two types: total factor productivity measures and net return measures.

Total factor productivity measures include the private and social benefit/cost ratios (PBC and SBC, respectively). The PBC is a measure of how efficiently a firm utilizes inputs to production, given these factors' current prices. The SBC is used to evaluate a firm's or an industry's efficiency when valuing production inputs at their economic prices (Liedholm and Mead 1987, Biggs 1986, Cortés et al. 1987).

Net return measures include the profit function, the entrepreneurial benefit-cost ratio (EBC), and net returns to family labor (Liedholm and Mead 1987; Little et al. 1987; Cortés et al. 1987; Biggs 1986). These measures provide an estimate of the net economic return to one selected factor of production (Liedholm and Mead 1987). The EBC measures the net return to the proprietor's efforts in production, which is then compared with the shadow price of proprietary labor. Liedholm and Mead (1987) use returns to (unpaid) family labor extensively to analyze efficiencies in various industries in several developing economies. This measure can be used to compare those returns with the shadow price of labor: "If the net return to family labor in an enterprise equals or exceeds the shadow wage of that labor, that enterprise can be considered to be economically efficient" (Liedholm and Mead 1987). The shadow wage here is the amount that a family worker could receive if employed elsewhere in the economy.

This measure appears particularly appropriate to activities in which family labor provides a large component of value-added (for example, in forest-based SSEs).

Choice of technology

The key to increasing employment in a given industry is to promote technologies which require a higher ratio of labor to capital than is currently used in production. White (1978) concludes in his survey that "evidence . . . suggests strongly that greater labor intensity in LDC manufacturing is feasible and would be efficient," given social prices for labor and capital. Although a significant portion of an industry may profitably use capital-intensive techniques, the true economic costs of labor and capital suggest the desirability of encouraging labor-intensive technologies. Profitable capital-intensive methods therefore exist in these economies only because of market distortions. Many distortions are caused by government policies. Among these are subsidies to capital, laws on minimum wages and benefits, export restrictions, import substitution strategies, and currency exchange-rate controls (White 1978, Morawetz 1974, Jansen and Ruiz de Gamboa 1987, Little 1987).

From a private efficiency standpoint, the firm seeks the technology which, given the current factor price ratios, optimally utilizes available financial resources to

produce a certain good. In an economy with perfect factor markets, this financial optimization is equivalent to economic optimization. Figure 1 illustrates this point. Tangency of the factor price ratio line with the production isoquant (I) indicates the most efficient combination of capital and labor. Given market distortions which make capital relatively cheaper and labor more expensive, the (financially) optimum factor combination is determined by line ab. Factor price ratio line cd indicates the most efficient factor combination for the economy if those distortions were removed and hence factors were valued at their economic prices. This illustrates true economic efficiency. Given the market distortions from the many possible sources, the latter factor input combination rarely if ever is observed.

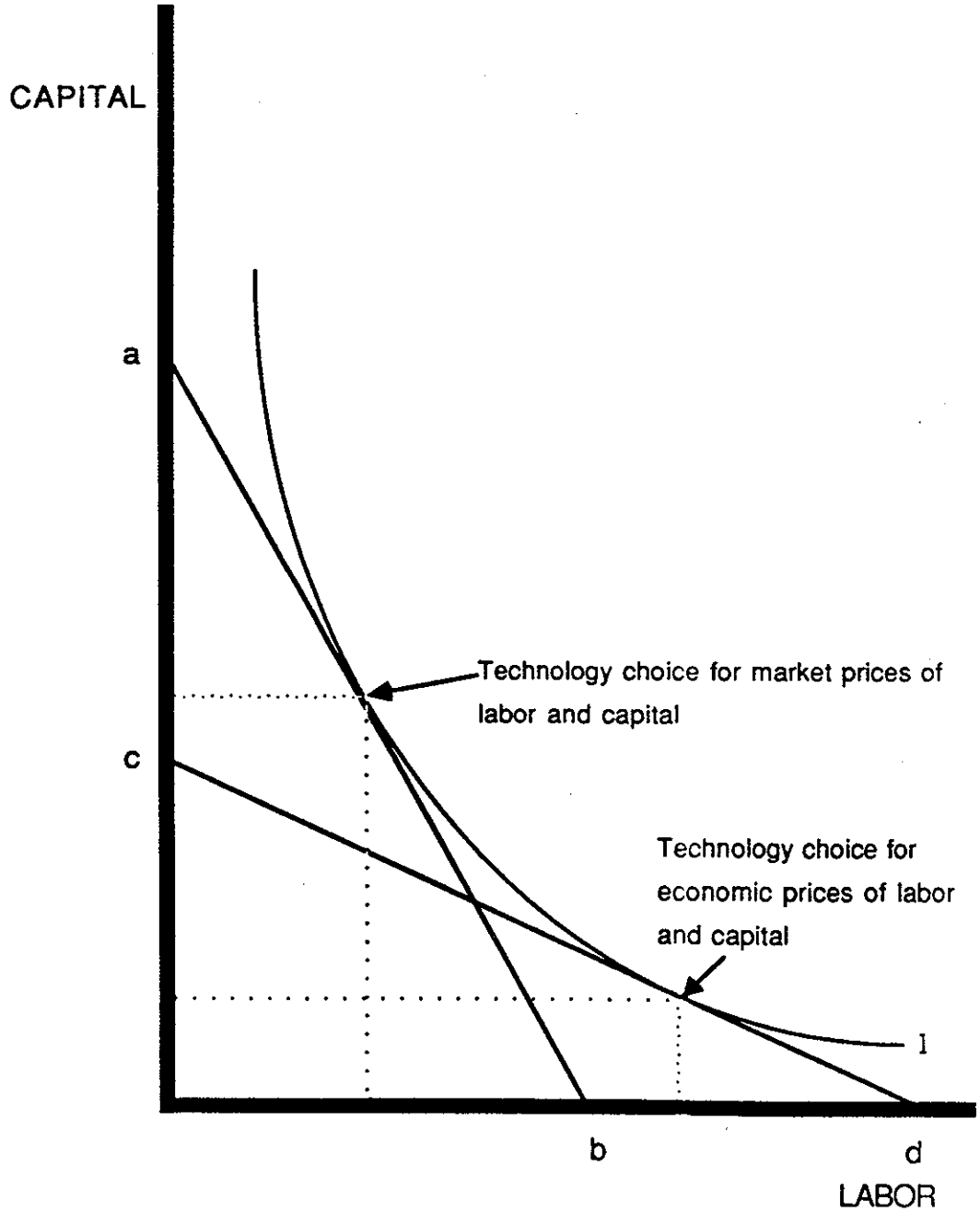

Figure 1. Optimal factor combinations in a manufacturing industry.

Even if a firm is purchasing labor and capital at their economic prices, efficiency can vary significantly between firms or industries. Reasons for these differences may include access to markets (often varying because of geography and level of development), prices for raw materials, prices for final products, the proportion of hired labor, and the proprietor's entrepreneurial ability (which may be a function of education and experience) (Cortés et al. 1987, White 1978).

EMPIRICAL RESULTS

Partial efficiencies

Partial efficiency measures help evaluate whether there is a trade-off between efficiency and employment promotion in Ecuador's sawnwood subindustries. Table 5 shows the various partial measures of efficiency. The values presented appear to demonstrate differences between subindustries. However, T-tests reveal that only capital productivity (in sucres of value-added per sucre of annual capital cost) varies significantly (alpha = 0.051) between motosierristas and small sawmills at the national level.

Table 5. Selected partial efficiency measures for the sawnwood industry of Ecuador, by technology and by region (1987).

Measure	Region	Technology	
		Motosierrista	Small Sawmill
FK/L[1]	Coast	4142	33748
	Amazonia	1459	6056
	Highlands	1582*	5279*
	All Regions	2167	17031
AK/L[2]	Coast	291	2695
	Amazonia	198	439
	Highlands	221*	438*
	All Regions	230	1361
VA/FK[3]	Coast	0.90	4.76
	Amazonia	3.88	0.76
	Highlands	0.20	2.68
	All Regions	1.68	3.23
VA/AK[4]	Coast	5.09*	65.61*
	Amazonia	38.60	27.16
	Highlands	0.49	30.53
	All Regions	15.17*a	43.93*a
VA/L[5]	Coast	8714	7618
	Amazonia	5129	4330
	Highlands	698*b	9312*b
	All Regions	4936	7867

Notes:
1. Sucres of fixed capital stock (buildings, machines, and vehicles) per unskilled-equivalent man-year of labor per year.
2. Sucres of annual capital cost per unskilled-equivalent man-year of labor per year.
3. Sucres of value-added per year per sucre of capital stock.
4. Sucres of value-added per sucre of annual capital cost per year.
5. Sucres of value-added per unskilled-equivalent man-year of labor per year.

a. Alpha = 0.051.
b. Alpha = 0.054.
* Indicate significant differences between technologies, at the 95% level of confidence.

When partial measures are disaggregated to the regional level, only in the highlands and the coastal region do the two technologies show significant differences. The data indicate that in the highlands, sawmills are more capital-intensive (alternatively, less labor-intensive) and enjoy higher capital productivities than do motosierristas. In the coastal region, sawmills obtain significantly higher (annualized) capital productivities than motosierristas. For Amazonia, T-tests reveal no significant differences in partial efficiencies between subindustries.

The data show that in at least one region, and probably nationally, sawmills are, perhaps surprisingly, given the low investment levels required for chainsaw lumber production, significantly more productive than motosierristas in the use of capital. In the highlands motosierristas are more labor-intensive (FK/L and AK/L), and sawmills more labor-productive (VA/L). This indicates a potential trade-off. In order to produce a given value-added of output, motosierristas require a higher input of labor than sawmills. However, because sawmills utilize less labor as well as less capital for producing that output, they are the more technically efficient.

Comprehensive efficiencies

Table 6 examines efficiency in terms of three comprehensive measures: the private, social, and

entrepreneurial benefit-cost ratios. The data indicate that, nationally and in the coastal and highlands regions, sawmills are more efficient than motosierristas. Only in Amazonia can the null hypothesis of equal efficiencies not be rejected.

Table 6. Selected comprehensive efficiency measures for the sawnwood industry of Ecuador, by technology and by region (1987).

Measure	Region	Technology	
		Motosierrista	Small Sawmill
Private Benefit-Cost Ratio[1]	Coast	0.36*	6.45*
	Amazonia	2.60	1.82
	Highlands	-0.25*	5.99*
	All Regions	0.91*	5.59*
Social Benefit-Cost Ratio[1]	Coast	0.66*	5.67
	Amazonia	3.08	1.97
	Highlands	-0.22*	5.63*
	All Regions	1.16*	5.12*
Entrepreneurial Benefit-Cost Ratio[1]	Coast	0.07*	6.01*
	Amazonia	2.25	1.27
	Highlands	-0.47*	5.83*
	All Regions	0.63*	5.26*

Notes: 1. See Appendix B for formulas and assumptions underlying these measures.

* Indicate significant differences between technologies, at the 95% level of confidence.

Table 7 compares returns to unpaid family labor (including proprietary labor) with wages paid to hired workers. If the returns to unpaid family labor are greater than the shadow price for that labor, then that firm or (sub)industry is successfully utilizing family and proprietary services (Liedholm and Mead 1987).

Table 7. Returns to family labor and monthly wages paid to hired workers in the sawnwood industry of Ecuador, by technology and by region (1987).

Measure	Region	Technology	
		Motosierrista	Small Sawmill
Returns to family labor[1] (sucres/mo.)	Coast	-8240[2]	365625
	Amazonia	44100	164342
	Highlands	-42800*	311242*
	All Regions	-3700*	310917*
Skilled wage (sucres/mo.)	Coast	45283	22031
	Amazonia	23000	23962
	Highlands	40000	16864
	All Regions	32821	20261
Unskilled wage (sucres/mo.)	Coast	24000	24727
	Amazonia	21000	18167
	Highlands	15200	13492
	All Regions	20261	18037

Notes:
1. See Appendix B for formula and assumptions in underlying this measure.
2. This value and other values shown are negative because the value-added is negative. See Appendix B.
* Indicate significant differences between technologies, at the 95% level of confidence.

T-tests indicate that, at the 95% level of confidence, net returns to unpaid family labor differ significantly between subindustries. Unpaid family workers in sawmills realize a higher net return than those in motosierristas operations. However, disaggregation to the regional level shows that this difference is weak (and insignificant in Amazonia).

The conclusion of low motosierrista factor efficiency cannot be accepted uncritically, however. Appendix C illustrates the effects of doubling the estimate of annual sales for both motosierristas and sawmills. This was done to evaluate the influence of underestimates by proprietors of sales. The result is a dramatic change in the levels of efficiency. Note, however, that the relative position of chainsaw technology as inferior remains unchanged.

Regression analysis was used to test correlation between the SBC and several possible explanatory variables. Variables tested were: age of firm, prices of roundwood and sawnwood, level of fixed and working capital, percent of self-financed capital, capital-labor ratios, the proportion of skilled labor, and the proportion of family labor in total labor.

Of these variables, only the proportion of family labor was able to significantly explain differences in social efficiency (as measured by SBC) between firms. For motosierristas, the proportion of family labor provided to

the firm was positively correlated with efficiency. Interestingly, there is a weak negative correlation between social efficiency and the proportion of family labor for sawmills. The latter relationship is consistent with results of Liedholm and Mead (1987), and could be attributed to higher-quality labor provided by hired labor in the sawmill than that provided by the owner's family. The inconsistency between subindustries implies that additional study is needed.

Conversion efficiency, a crude measure of technical efficiency, is shown in Table 8. According to studies by Guerrón (1988a) and Guevara (1987), motosierristas appear to obtain a greater physical yield from roundwood than do sawmills. The data presented appear to contrast with the observation by Cortés et al. (1987) that technical efficiency is the greatest contributor to private efficiency for two industries studied in Colombia. However, the conversion differences are small, and variability in production is large. This lessens the confidence that the measures presented are significantly different between subindustries. The present study suggests that, although sawmills have conversion efficiencies that are, at best, equal to those of motosierristas, they utilize other inputs more efficiently than motosierristas (Molinos 1987).

Table 8. Conversion efficiency (from log to final product) in sawnwood production in Ecuador, by diameter class of log and technology (1987-1988).

Diameter Class (centimeters)	Technology		
	Motosierrista[1]	Small	Sawmill[2]
	. . . . . Efficiency (%)		
< 30	47	36	
30-39.9	50	41	
40-49.9	51	45	
> 50	49	41	

Notes: 1. Adapted from: Guerrón 1988a.
2. Adapted from: Guevara 1987.

Employment implications

An analysis was conducted on the theoretical effects of implementing a policy which would eliminate or restrict the operation of motosierristas as the less efficient sawnwood technology. The effects of two scenarios are given in Table 9. The first scenario evaluates employment effects if all sawnwood currently produced by motosierristas were to be produced by only small sawmills. The second scenario considers the impacts if sawmills replaced motosierristas only in the two regions where sawmills are more efficient, the coast and highlands. It is assumed that aggregate industry supply is held constant, even though this simplifies from a complex adjustment problem.

Table 9. Employment impact if sawmills replaced motosierristas for industry output held constant (1987).

Coefficient Used	Scenario 1: All Region			
	Hired Labor		Unpaid Labor[1]	
	Loss/Gain (man-years)	% Change	Loss/Gain (Man-years)	% Change
Value-added per man-year	+47	+1.3	-8590	-88.0
M^3 sawnwood per man-year	-19	-0.5	-9087	-93.1

Table 9. (continued)

Coefficient Used	Scenario 2: Regions Where Sawmills Are Most Efficient[2]			
	Hired Labor		Unpaid Labor[1]	
	Loss/Gain (man-years)	% Change	Loss/Gain (Man-years)	% Change
Value-added per man-year	-515	-14.2	-5932	-60.7
M^3 sawnwood per man-year	-366	-10.1	-5928	-60.7

Notes: 1. Proprietors and unpaid family labor.
2. Coast and highlands (see text).

Employment changes are estimated using two ratios. The first is the value-added to labor ratio. The second is the volume of output to labor ratio.

The change in hired labor ranges from a fall of 14.2 percent to a rise of 1.3 percent. More important is the change in unpaid (proprietary and family) labor, which falls by a minimum of 60.7 percent. Approximately 9,087 unpaid workers are displaced in the worst-case scenario. This is an upper limit, given that the rest of the economy would absorb a proportion of these individuals in alternative activities.

SUMMARY AND CONCLUSIONS

Although motosierristas and small sawmills each play a key role in certain submarkets, there is sufficient market overlap to justify an evaluation of the choice of technology. Sawmills exhibit higher factor productivities than motosierristas in the highlands and the coastal regions. Motosierristas in the highlands are more labor-intensive than sawmills, indicating a potential trade-off between employment and productivity in that region. Comprehensive measures of efficiency indicate that sawmills are more efficient than motosierristas, except in Amazonia. Of the variables tested, only the firm's proportion of hired labor is correlated with differences in efficiency (although this relationship is not well understood).

This study was unable to identify the major causes for variations in efficiency between subindustries and among firms within subindustries. This is the result of two important factors which should be taken into account when similar studies are attempted in the future. First is the inaccuracy and extreme variability in values of important flow variables, resulting from the difficulty of obtaining accurate estimates. This is inherent in survey methods which do not monitor flows over a substantial period of time. A second problem was the failure to identify, before beginning fieldwork, certain key variables which could explain efficiency. Among these are experience of the proprietor, education of the proprietor, and exact operating time per year.

If efficiency is the major goal of the forest-based sector, then infrastructural development should be a high priority in Amazonia. This could promote the feasibility of fixed-plant sawmills and hence help raise factor productivity. On the other hand, if maintenance of rural employment levels is indicated, motosierristas should be the technology of choice. Motosierristas utilize more labor per unit of value-added output than sawmills, and they provide work to thousands of rural laborers. Motosierristas also currently supply most of the raw material required by the secondary processing industry, which is also labor-using.

If decision makers want to both improve efficiency and promote employment, then the apparent employment/efficiency trade-off makes the choice between sawmills and motosierristas very difficult. However, decisions could be informed through: (1) further research into the underlying determinants of technical efficiency; (2) identification and promotion of firms possessing such characteristics; (3) road construction in areas where sawmills are presently inefficient (including Amazonia); (4) investigation into conversion efficiency-enhancing technologies for motosierristas; and (5) definition of other policies designed to eliminate inefficient firms while encouraging efficient ones.

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APPENDIX A: SURVEY METHODS

The data for this study form part of a nationwide investigation of the entire forest industry of Ecuador. The national study covered wood depots and wood workshops as well as the motosierristas and sawmills.

The proprietors of forest products firms were interviewed for information on consumption of raw materials, production, employment, exports, investment levels, inventory, current debt levels, other costs of production, tax costs, affiliation with industrial associations, plans for future investment and perceived need for training of employees and management.

A quota sampling design was developed which incorporated elements of cluster, snowball, and panel sampling. All nineteen continental provinces (i.e., excluding the Galápagos Islands) and a total of sixty-four localities were surveyed. Each province was divided into subregions, or localities. The number of firms sampled in each locality was based on forest industry expert estimates of the area's level of forest products activity. That estimate determined the localities' number of enterprise sampling clusters assigned. A questionnaire was developed by forestry and economic experts and field-tested for one week prior to finalization of format.

Six cluster types were formulated, each consisting of varying combinations of sawmills, motosierristas, wood

depots, and workshops. Each cluster consisted of a group of four sampled firms. The maximum for any locality was sixteen clusters, and the minimum was one.

After choosing the assigned number of clusters randomly from among the six cluster types, crew members randomly selected businesses to sample. In order to increase response rates, firm owners were promised that they would receive a report of the survey results after compilation in 1988. Some proprietors were also given an informational newsletter, produced by FPEI personnel, which listed current prices for wood products in Ecuador.

Aside from the questionnaires, a nationwide field count of firms was performed. Table A1 shows the numbers of firms sampled and an estimate of the national population of firms for each region. Firms were tallied in the sixty-four surveyed localities as well as along roads and in communities en route between clusters. The enumeration data, though certainly incomplete, provided a more accurate estimate of the number of firms than the predetermined levels.

Table A1. Number of counted and surveyed forest products firms in Ecuador, by region and by subindustry (1987)1.

Subindustry	Coast		Amazonia		Highlands		Total	
	Count	Sur.	Count	Sur.	Count	Sur.	Count	Sur.
Motosierristas[2]	1654	43	1308	34	1538	40	4500	117
Sawmills[3]	139	31	16	9	157	28	312	67
Depots	406	62	21	11	310	65	737	138
Converters	1420	39	41	9	915	44	2376	92
Others[4]		10		4		27		41

Notes:
1. The actual number of firms is higher for sawmills, depots, converters, and "others." An estimated 60-70% of all firms in the country were tallied because not all localities were visited.
2. Calculated estimate. See text.
3. Of the total sampled number, 63, or 94%, are classified as small scale enterprises (i.e., the firm utilizes a maximum of 10 person-years of hired labor).
4. These included firewood depots, tree nurseries, timber plantation owners, plywood plants, veneer plants, particleboard plants, and pitsawn lumber operations.

It was financially impractical to perform such a count of motosierristas because most of these operate in areas remote from communities and major roads. To estimate their numbers, an indirect method was used. First was calculated the total annual volume of sawnwood that is produced by motosierristas and sold to secondary manufacturing firms. This was estimated by asking proprietors of secondary manufacturers the percentage of sawnwood deriving from motosierristas. Second, the total volume of sawnwood coming from motosierristas was divided by the average annual volume produced by motosierristas.

A sub-study on conversion efficiency (of roundwood to sawnwood) and daily production for motosierristas was also performed. Information was gathered through observation of a selected group of nine motosierristas that work in a lowland humid tropical forest in the provinces of Esmeraldas and Pichincha. The subjects were observed for the duration of processing a tree into sawnwood, including felling, bucking, sawing, and maintenance and repair of chainsaws. Logs were measured for merchantable volume using a simple log scale formula[1]; products were measured afterwards. A simple ratio of product volume to log volume

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1. This formula was, for logs:

$$V=\frac{(\text{Diameter})^2 \times \text{Length} \times 3.1416}{4}.$$

For wood products, the formula used was:

$$V=\text{Length} \times \text{Width} \times \text{Thickness}.$$

gives the estimated conversion efficiency.

A major problem that was recognized after surveying was completed was inaccuracy of data on flow variables (especially on roundwood and sawnwood volumes). Possible reasons for this include: dishonesty stemming from distrust of the surveyors, inadequate record-keeping, and poor memory recall on the part of the proprietors. These problems are common to surveys of this type in developing countries (for example, see Liedholm and Mead 1987). Clearly, there is room for error in the survey data.

In an attempt to address this problem, a sub-sample of firms that were previously surveyed was performed in July, 1988. The purpose of the sub-sample was to develop a correction factor for consumption and production. The null hypothesis for performing the sub-sample was that responses in 1988 would be the same as those in 1987. Thirty-one proprietors from the original survey (three from motosierristas, eight from sawmills, ten from wood depots, and 10 from converters) were reinterviewed. Assuming no regional differences in data inaccuracy or bias, these firms were chosen from areas of highest forest products activities[2].

Results indicate insufficient evidence for rejecting the null hypothesis. No clear trend was found in over- or

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2 This meant sampling sawmills and motosierristas in the coast and secondary manufacturing firms in the highlands.

underestimation of key production variables. Therefore, a correction factor could not be applied to the data.

Structural problems also surfaced during the original survey. These included transportation restrictions, refusal to interview (the refusal rate was approximately 10%), and inaccurate transfer of data to questionnaire forms.

APPENDIX B: BENEFIT-COST RATIOS

Three major benefit-cost ratios used in this study are the Entrepreneurial (EBC), Private (PBC), and Social (SBC).

The EBC assumes that the proprietor's basic objective is to maximize the return on his own capital and labor inputs in the enterprise. In the numerator the formula subtracts from value-added (the result of subtracting the value of all purchased inputs from total sales) the cost of borrowed capital and the cost of hired labor. In the denominator is found the cost of self-financed capital and the opportunity cost of the family and proprietary labor.

The EBC examines how well the proprietor utilizes his[3] expertise to cover his share of fixed and variable costs. A ratio of greater than one indicates that all costs are covered and that he is earning significant profits. A ratio of less than one but greater than zero indicates that he generates at least positive value-added, but not enough to cover all of his costs. A ratio of less than zero indicates that he is not generating enough value-added to cover any of his costs (Cortés et al. 1987).

The PBC relates total benefits to the costs of all resources employed by the enterprise. In the numerator is found only value-added. The denominator includes capital costs from all sources (self-financed and borrowed) and the

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3 Masculine pronouns will be used here, given that the overwhelming majority of proprietors are men.

wage bill (including hired labor and the opportunity costs of the proprietor's and family's labor).

The SBC normally works exclusively with opportunity costs. In the numerator is value-added. In practice, the denominator includes one social opportunity cost of capital applied to all capital (working and fixed), plus the cost of labor valued at its opportunity cost. The SBC can be used to compare efficiencies between firms and groups of firms within industries if domestic prices are used in the calculations of the value-added and capital inputs to production. To compare between industries one must use "world" or "border" prices (Little 1987; Liedholm and Mead 1987). Border prices are the c.i.f and f.o.b. prices of tradable inputs and tradable outputs of production, respectively (Jansen and Ruiz de Gamboa 1987). An Social Benefit-Cost Ratio of greater than 1.0 indicates that a firm or industry has a positive effect on the total output of the economy; a ratio of less than one implies a negative effect (Biggs 1986; Liedholm and Mead 1987).

Calculations

1. The Private Benefit-Cost Ratio was calculated as follows:

$$PBC = \frac{VA}{rK + wL}$$

where: VA = value-added, calculated as the net of sales minus all purchased inputs to production (i.e., neither working or fixed capital nor the cost of labor are

subtracted from total sales);

r = a weighted average of interest rates corresponding to the enterprise's various credit sources, including the proprietor's own capital;

wL = the firm's wage bill, including the opportunity cost of family and proprietary labor;

K = the firm's total fixed and working capital.

In this study, value-added is in sucres per year. The interest rate is assumed to be 7.5% for borrowed capital and 1% for self-financed capital. The 1% figure was arrived upon after considering that most owners of very small enterprises have very little money to invest. The little money that they could invest would most likely go to a commercial bank savings account, many of which (or, rather, during this period, <u>most</u>, if not <u>all</u> of which) paid a negative real rate of return at the time of the survey (McMullen 1988). Currency speculation (purchase of dollars, for instance), on the other hand, although risky, would probably have been the highest-returning investment.

Fixed capital is in terms of buildings, machines, forestry equipment, and vehicles. Working capital is taken to be the value of inventory (Liedholm 1988). The opportunity costs of family and proprietor labor were calculated as follows:

(1) The opportunity cost of family labor was assumed to be one-half of the average monthly wage paid to

unskilled workers in the same technology and region. This was multiplied by 12 to obtain annual values.

(2) The opportunity cost of proprietor labor was assumed to be the average monthly wage of skilled workers in the same technology and region. This wage was multiplied by twelve to obtain an annual value[4].

2. The Social Benefit-Cost Ratio was calculated as follows:

$$SBC = \frac{VA}{r_s + w_s L}$$

where: VA = value-added, calculated as in No. 1, above;

r_s = the opportunity cost of capital, usually one rate across all sources of capital ($r_s K$ was calculated using the Capital Recovery Factor (see Number 5, below)), fixed and working;

w_s = the opportunity cost of labor for each skill category, including the opportunity cost of family and proprietary labor.

The opportunity cost of capital is taken as 7.5%. The opportunity cost of each hired worker was taken as the 10th-percentile monthly wage. This was disaggregated to

4. For motosierrista firms, only five firms sampled paid skilled laborers' wage. The average of those wages (31867 sucres/month) was assumed to be the motosierrista's opportunity cost.

skill category (administrative, skilled, and unskilled), subindustry, and region (coast, highlands, Amazonia). This value was multiplied by 12 months to obtain an annual opportunity cost of hired labor.

Family and proprietary labor opportunity costs were calculated as in Number 1, above.

3. The Entrepreneurial Benefit-Cost Ratio was calculated as follows:

$$EBC = \frac{VA - [r_b K(b) + w_h L(h)]}{r_o K(o) + w_o L(o)}$$

where: VA = value-added, calculated as explained above, in sucres per year;

$r_b K(b)$ = the cost of borrowed capital, including ($r_1 K_1$), the cost of borrowed fixed capital, and ($r_2 k_2$), the cost of borrowed working capital;

$w_h L(H)$ = the cost of hired labor;

$r_o K(o)$ = the opportunity cost of the proprietor's self-financed capital. It also includes fixed and working capital;

$w_o L(o)$ = the opportunity cost of proprietary and family labor.

In this study, it is assumed that $r_1 = r_2 = 7.5\%$. Working capital is taken as the value of inventory.

The opportunity cost of the proprietor's self-financed capital (comprising an average of approximately 88.6% of the firm's total capital in the primary industry) was assumed to be 1% (as explained above).

The opportunity costs of family and proprietary labor

were calculated as explained in Number 1, above.

4. The returns to family labor were calculated using the following formula:

$$RFL = \frac{VA - (wL_h - rK)}{H_f}$$

where:

RFL = net returns to family labor;

VA = value-added;

wL_h = the wage bill for all hired labor, valued at its shadow price;

rK = the annual cost of capital, valued at its shadow price;

H_f = hours of family labor, including those of the proprietor.

The opportunity cost of capital is the sum of the cost of borrowed plus self-financed capital, as explained in Number 3, above. The hours of unpaid family labor per person per year were assumed to be equal to 1200 for motosierristas and 1300 for small sawmills.

5. The annual cost of capital was calculated using the capital recovery factor (CRF), taken from Liedholm and Mead (1987):

$$CRF = R = \frac{rV}{1 - (1 + r)^{-n}}$$

where: R = annual capital cost;

r = interest rate;

V = present value of the unit of capital;

n = average expected life (in years) of the unit of capital.

The present value of a unit of capital was determined by taking either the proprietor's estimate of the unit's present value or, if the proprietor could not estimate, the unit's original purchase price. That purchase price was inflated to 1987 sucres (average of September and October) using the Ecuadorian Central Bank's consumer price indices (Banco Central Del Ecuador 1977; Banco Central del Ecuador 1987), base 1970 = 100. Capital was then depreciated proportionately each year from the date of the purchase, to a minimum of 10% of the present value of its original purchase price (i.e., its salvage value).

The average expected life of the units of capital were assumed as follows:

* buildings, 20 years;
* vehicles, 10 years;
* machines, 15 years;
* forestry equipment, 4 years.

Land was not included in the capital stock.

APPENDIX C: SENSITIVITY ANALYSIS--

EFFECTS OF A CHANGE IN TOTAL VALUE OF ANNUAL SALES

A hypothesis arising from interviews is that sales values were underestimated significantly by interviewees. This would occur if interviewers were considered suspiciously as agents from, or informants to, the government.

Table C1 analyses the effects on calculated benefit-cost ratios of a doubling the value of the firm's total sales. Note that benefit-cost ratios change dramatically, in many cases lifting a technology in a region from non-beneficial to the economy or very uncompetitive to very beneficial or competitive.

These results underscore the importance of obtaining accurate estimates of total sales for firms. If comparisons of efficiency in factor use are made, then a bias in sales can have a tremendous impact.

Table C1. Effects on benefit-cost ratios from doubling the value of annual sales for sawnwood production, by technology and by region (1987).

Measure	Region	Sales	Technology: Motosierrista	Technology: Small Sawmill
Social Benefit-Cost Ratio	Coast	Normal	0.65*	5.67*
		Doubled	5.55*	17.14*
	Amazonia	Normal	3.08	1.97
		Doubled	9.13	8.83
	Highlands	Normal	-0.22*	5.63*
		Doubled	3.60*	15.05*
	All Regions	Normal	1.16*	5.12*
		Doubled	5.22*	9.48*
Private Benefit-Cost Ratio	Coast	Normal	0.36*	6.45*
		Doubled	5.42*	18.39*
	Amazonia	Normal	2.60	1.82
		Doubled	7.58	7.59
	Highlands	Normal	-0.25*	5.99*
		Doubled	3.18*	15.71*
	All Regions	Normal	0.91*	5.59*
		Doubled	5.27*	15.64*
Entre-preneurial Benefit-Cost Ratio	Coast	Normal	0.67*	6.01*
		Doubled	5.12*	18.21*
	Amazonia	Normal	2.25	1.27
		Doubled	7.24	7.13
	Highlands	Normal	-0.47*	5.83*
		Doubled	3.00*	16.10*
	All Regions	Normal	0.62*	5.26*
		Doubled	5.00*	15.68*

Notes: * Indicate significant differences between technologies, at the 95% level of confidence.

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