AN ANALYSIS OF THE MARKET POTENTIAL OF CHILEAN HARDWOODS

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ABSTRACT

A model to classify hardwood species for furniture applications in Pacific Rim markets was developed using discriminant analysis. The results suggest that the technique could be used for other specific product/market applications. The results also indicated that the Chilean hardwood species have the desired properties for use in furniture making and that they would probably substitute for tropical hardwoods instead of the North American hardwoods in this rapidly expanding market.

Keywords: Hardwood species, discriminant analysis, Pacific Rim markets.

INTRODUCTION

An active market exists for hardwood species in the Pacific Rim countries of South Korea, Taiwan, and Japan. Major uses for hardwood species in the Pacific Rim include plywood, veneer, structural/construction applications, furniture, musical instruments and other appearance applications (Araman 1987; Govett et al. 1987; Hansen and Araman 1986). These applications result in distinctive market niches.

A variety of opinions exist regarding the future potential of many tropical and temperate hardwood species (Bethel 1984; Eddowes 1984; Erfurth 1976; Plumptre 1972; Towler 1975). Although economic factors might help explain the acceptance of some species in specific markets, the current lack of economic analysis is a constraining factor in assessing future market potential for the species (Vincent

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et al. 1989). In addition, the continued demand for high quality logs and lumber products and restrictions on traditional Southeast Asian hardwood suppliers have renewed interest in developing hardwood resources in other parts of the world.

Tests are being conducted on potential substitute species, particularly for plywood manufacturing and construction applications by traditional importers of hardwood species such as Japan (Schreuder and Volsky 1985). These efforts offer many market opportunities for potential hardwood and softwood substitute species from emerging forest products exporters such as Chile.

Chile has about three million hectares of temperate hardwood forests considered suitable for commercial forest management (Ulloa 1984). The most promising areas are second-growth stands and some old growth areas are in Region X of Chile (Fig. 1). This region accounts for 47% of the total commercial hardwood area in the country and comprises 81% of the country's total hardwood inventory (Corporación Nacional Forestal 1988).

The use of hardwood species by Chile's forest products industry has increased in recent years. Current uses include wood chips, veneer, lumber, and furniture parts and pieces (Infor-Corfo 1989). Most current production is sold overseas; however, particular emphasis is being placed on expanding the production of value-added products such as veneer, finished lumber, and furniture parts and pieces. Chilean value-added hardwood exports have increased significantly over the past four years (Anonymous 1988; Infor-Conaf 1989). According to Chilean sources, the production and export of hardwood boards and furniture parts are considered among the most promising opportunities for increased exports of value-added products over the next five years (Jélvez et al. 1989). Unfortunately, the Chilean temperate hardwoods are almost totally unknown in the international marketplace at the present time and their potential suitability as substitutes for either North American or tropical hardwoods has not been previously evaluated.

Marketing research on the potential substitutability among hardwood species in the market place is limited. Classification procedures are necessary to group similar species for specific end-uses. Such procedures would allow one to group different species based on their underlying properties. This is particularly important in evaluating the market potential of hardwoods, because of the wide range of properties associated with these species.

Several multivariate techniques exist and have been used as classification tools in marketing research. Cluster analysis is often used for market segmentation, assessing potential market opportunities and the development of a better understanding of consumer behavior (Hagerty 1985; Klastorin 1983; Punj and Stewart 1983). Cluster analysis is particularly useful in exploratory work where the analyst is seeking to identify natural groupings in the data and has no a priori groups of particular interest. Given the exploratory nature of this statistical tool and large number of relatively arbitrary methods for assigning individual observations to specific groups or clusters, this powerful tool has often been misapplied in past research. The use and misuse of cluster analysis are well documented in the literature (Hagerty 1985; Stewart 1981). Cluster analysis also requires the use of continuous data for model development.

Discriminant analysis, another commonly used marketing research tool, allows the researcher to evaluate differences between two or more groups of objects with respect to several variables simultaneously. This technique also provides a means

FIG. 1. Geographic location of existing plantations and native forests in Chile.

of classifying an individual observation into the group of which it would most likely be a member. Unlike cluster analysis, discriminant procedures require the groups to be defined a priori and the units of analysis to be members of two or more mutually exclusive groups (Johnson and Wichern 1988; Klecka 1988). This technique has the added advantage of allowing the use of both continuous and ordinal data.

The objectives of this paper are 1) to develop a general approach for classifying relatively unknown species for specific product/market applications based on a priori market conditions, and 2) to provide an assessment of the potential substitutability of Chilean temperate hardwoods relative to North American temperate and tropical hardwoods in the major Pacific Rim markets in furniture applications. The approach developed in this paper should be of interest to a broad array of market analysts attempting to evaluate the potential market roles of many of the worlds' relatively unknown species. The results also provide hardwood producers and consumers with a better understanding of the potential role of this relatively undeveloped resource.

SPECIES GROUPINGS

The twenty-one hardwood species most commonly imported by the Pacific Rim countries of Japan, South Korea, and Taiwan were used in this study for classification purposes. Ten relatively unknown Chilean hardwood species were used to evaluate model suitability and to assess Chile's future market role. A list of the different species included in this study is presented in Table 1.

The assignment of the species to the different groups is a key step in model development and is somewhat subjective. Non-Chilean hardwood species were assigned to three groups: tropical hardwoods, temperate hardwoods originating from Canada and the United States, and high value specialty species. These were designated as groups 1, 2, and 3, respectively. Group 1 was composed of nine tropical hardwood species. Group 2 included 12 North American temperate hardwood species. Species such as ebony and teak commonly imported by Pacific Rim countries were considered specialty species for furniture applications and were therefore assigned to group 3.

It is important to recognize that the groupings developed in this study represent only one of many possible grouping alternatives. The definition of the different groups and number of different groupings would, in most cases, depend primarily on the objectives of the analyst.

DATA

Eight properties were compiled for the hardwood species used in the analysis (Table 2). The list of variables was constrained by the literature published on selected species, and only those properties considered of the greatest importance in furniture manufacturing were used in this study. The properties included color, durability, treatability, texture, workability, finishing, gluing, and shrinkage. Data on the properties of North American temperate species and for the tropical species considered were obtained from Chudnoff (1984), Forest Products Laboratory (1987), Haygreen and Bowyer (1982), Patterson (1988), Towler (1975). For the Chilean hardwoods, data published by Conaf (Corporación Nacional Forestal) and Infor (Instituto Forestal) were used (Díaz-Vaz et al. 1987; Pérez 1983). Ordinal

TABLE 1. *Botanical and commercial names for hardwood species of the Pacific Rim.*

Commercial name	Botanical name
Dark Red Lauan	*Shorea negrosensis*
Light Red Lauan	*Shorea almon*
White Lauan	*Pentacme contorta*
Sepetir	*Pseudosindora palustris*
Apitong	*Dipterocarpus* spp.
Teak	*Tectona grandis*
Bintangor	*Cellophym* spp.
Keruing	*Dipterocarpus gendi*
Jelutong	*Dyera costulata*
Walnut	*Juglans nigra*
Sugar Maple	*Acer saccharum*
Beech	*Fagus* spp.
Elm	*Ulmus rubra*
Black cherry	*Prunus serotina*
White Oak	*Quercus alba*
Northern red oak	*Quercus rubra*
Southern red oak	*Quercus falcata*
Coigue*	*Nothofagus dombeyi*
Ulmo	*Eucryphia cordifolia*
Raulí*	*Nothofagus alpina*
Lingue*	*Persea lingue*
Laurel*	*Laurelia sempervirens*
Tineo*	*Weinmannia trichosperma*
Olivillo*	*Aextoxicon punctatum*
Roble*	*Nothofagus obliqua*
Lenga*	*Nothofagus pumilio*
Tepa*	*Laurelia philippiana*
Red alder	*Alnus rubra*
African Ebony	*Diospyros* spp.
Ramin	*Gonystylus bancanus*
White ash	*Fraxinus americana*

* Denotes Chilean hardwood species.

values (or where necessary, categorical values) were assigned for all properties except for volumetric shrinkage. Numerical values were used for volumetric shrinkage.

ESTIMATION AND RESULTS

Forward stepwise discriminant analysis was used to select the best discriminators. A significance level of 0.15 to enter and stay was chosen for the initial screening phase. Wilk's lambda was employed as a criterion for selecting the final variables. Five variables were selected based on this analysis, including durability, shrinkage, treatability, finishing, and workability. The significance of the variables ranged from 0.0001 to 0.0029. Parameter estimates and other statistical estimates related to the models are presented in Table 3.

Canonical discriminant functions for the hardwood species (excluding the Chilean species) were estimated next. The prior proportional probabilities were specified in the algorithm. The algorithm estimates the squared generalized distances between the groups by using the Mahalanobis's distance formula. The linear discriminant functions derived are presented in Table 3. In group 3 all variables

TABLE 2. *Coding of the different properties for hardwood species.*

Code	Classification
	Color
1	Whitish, pale brown, pale yellow, straw
2	Dark brown
3	Pink or red tints, including red brown
4	Other colors (black, purple, etc.)
	Heartwood durability
1	Very durable
2	Durable
3	Moderately durable
4	Nondurable
5	Perishable
	Heartwood treatability
1	Permeable
2	Moderately resistant
3	Resistant
4	Extremely resistant
	Finishing
1	Excellent
2	Good
3	Fair or medium
	Texture
1	Close or fine
2	Medium fine
3	Medium coarse
4	Coarse
	Workability
1	Very good or excellent
2	Easy or good
3	Poor or difficult
	Gluing
1	Excellent
2	Good
3	Fair or satisfactory

TABLE 3. *Linear discriminant functions for hardwood species derived from discriminant analysis.*

Variable	Groups 1	Groups 2	Groups 3	Level of significance[1]
Constant	−50.91500142	−43.83298294	−32.56134877	
Durability	11.45157179	9.82130046	4.12475342	0.0029
Treatability	6.66374762	4.30684742	6.26043449	0.0003
Finishing	23.11711056	17.44513600	13.99904205	0.0002
Workability	−4.84696852	−3.66640049	3.29019948	0.0001
Shrinkage	1.87706438	2.47682315	0.95041209	0.0007

Constant = $-0.5\ \bar{X}j'\ Cov^{-1}\ \bar{X}_j + \ln$ prior j; coefficient vector = $Cov^{-1}\ \bar{X}_j$.
[1]Equivalent to Prob < Lambda.

TABLE 4. *Classification scheme for hardwood species by using Discriminant Analysis.*

Obs.	Species	From group	Classified into group	Posterior probability of membership in group 1	2	3
1	DR Lauan	1	1	0.5532	0.4468	0.0000
2	LR Lauan	1	2*	0.2473	0.7527	0.0000
3	W Lauan	1	1	0.9993	0.0007	0.0000
4	Sepetir	1	1	0.9901	0.0090	0.0009
5	Apitong	1	1	0.9680	0.0320	0.0000
6	Teak	3	3	0.0000	0.0000	1.0000
7	Bintangor	1	1	0.9831	0.0169	0.0000
8	Keruing	1	1	0.9680	0.0320	0.0000
9	Jelutong	1	1	0.9534	0.0466	0.0000
10	Walnut	2	2	0.0711	0.9289	0.0000
11	S Maple	2	2	0.2054	0.7946	0.0000
12	Beech	2	2	0.0017	0.9983	0.0000
13	Elm	2	2	0.0127	0.9873	0.0000
14	B Cherry	2	2	0.0041	0.9945	0.0015
15	W Oak	2	2	0.2973	0.7019	0.0008
16	NR Oak	2	2	0.3202	0.6798	0.0000
17	SR Oak	2	2	0.1004	0.8996	0.0000
18	Red Alder	2	2	0.0794	0.9206	0.0000
19	A Ebony	3	3	0.0000	0.0000	1.0000
20	Ramin	1	2*	0.3605	0.6395	0.0000
21	W Ash	2	2	0.0537	0.9463	0.0000
22	Coigue		1	0.7066	0.2934	0.0000
23	Ulmo		1	0.9014	0.0986	0.0000
24	Rauli		1	0.9867	0.0133	0.0000
25	Lingue		1	0.9995	0.0005	0.0000
26	Laurel		1	0.7040	0.2960	0.0000
27	Tineo		1	0.9681	0.0319	0.0000
28	Olivillo		1	0.9946	0.0054	0.0000
29	Roble		1	0.9989	0.0011	0.0000
30	Lenga		1	0.9987	0.0013	0.0000
31	Tepa		1	0.9946	0.0054	0.0000

* Misclassified observation. Generalized Squared Distance Function: $D^2j(X) = (X - X_j)' COV^{-1}(X - X_j) - 2 \ln Prior_j$; Posterior Probability of Membership in each group: $PR(J \mid X) = \exp(-0.5D^2_j(X))/\Sigma_u(\exp(-0.5D^2(X)))$.

show positive coefficients in the linear function. In groups 1 and 2 only the variable "workability" shows an inverse relationship. The linear combinations of the discriminating variables were then used to classify the species into the different groups and to estimate their posterior probabilities of group membership (Table 4). The estimated discriminant functions correctly classified 90% of the species evaluated. In addition, the posterior probabilities of group membership were very distinctive for almost all the species considered in this study suggesting that the underlying assumptions of discriminant analysis are met (Klecka 1988).

Two species of the original 21 species selected for use in the model development phase of the analysis were misclassified—light red lauan (*Shorea almon*) and ramin (*Gonystylus bancanus*)—and confirmed by their respective posterior probabilities (Table 4). In each case the misclassified species were placed in group 1 by the discriminant analysis functions, instead of group 2 as originally assigned. These results suggest that although these species are tropical hardwoods, they more closely resemble temperate species used in traditional furniture applications. Further, dark red lauan (*Shorea negrosensis*) was correctly classified in group 1.

However, the posterior probabilities and classification score calculated for dark red lauan place it on the group margin.

Chilean hardwood species were then classified using the linear discriminant functions previously estimated. All species were classified in group 1 based on their respective posterior probabilities of group membership (Table 4). These results suggest that Chilean temperate hardwood species may likely be used in furniture applications currently reserved for tropical hardwoods and would substitute directly for many of these tropical hardwoods.

CONCLUSIONS

A model to classify hardwood species used in furniture manufacturing was developed by using discriminant analysis. The results suggest that as Chilean hardwood species may find greater use in furniture applications, these species would more likely tend to be a substitute for tropical hardwoods rather than North American hardwoods, based solely upon their wood properties as related to commonly used commercial hardwoods. This substitution potential is important to North American producers because Chile has the potential to become a competitor in the hardwood market in the years to come. The results also provide Chilean exporters with important market insights, which are critical to the efficient development of new markets for relatively unknown temperature hardwoods common to southern portions of Chile. Substitution possibilities should also be of interest to furniture manufacturers and other Pacific Rim importers of North American temperate and tropical hardwoods, given the increasing number of countries that have recently placed restrictions on the export of tropical logs.

REFERENCES

ANONYMOUS. 1988. El Mercado de Valor Agregado en Estados Unidos. *In* Boletín de Mercado. Corporación Nacional Forestal, Septiembre.

ARAMAN, P. A. 1987. U.S. hardwood trade in the Pacific Rim. Pages 99–104 *in* Proceedings of the Third International Symposium on World Trade in Forest Products. University of Washington, Seattle, WA.

BETHEL, J. S. 1984. Sometimes the word is "weed": a critical look at lesser-known species. Unasylva 36(145):17–22.

CHUDNOFF, M. 1984. Tropical timbers of the world. Agriculture Handbook. 607. U.S. Department of Agriculture, Forest Service, Washington, DC. 466 pp.

CORPORACIÓN NACIONAL FORESTAL. 1988. El Sector Forestal, Décima Región. Boletín Estadístico N 25. 43 pp.

DÍAZ-VAZ, J. E., F. DEVLIEGER, H. POBLETE, AND R. JUACIDA. 1987. Maderas Comerciales de Chile. Colección Naturaleza de Chile, Volumen 4. Editorial Alborada, Valdivia. 78 pp.

EDDOWES, P. J. 1984. Indonesia, Malaysia, Philippines, Singapore: Utilization of small dimension logs and underutilized timber species. FO:RAS/78/010, Working Paper No. 28. FAO Asia Pacific Forest Industries Development Group, Kuala Lumpur. 53 pp.

ERFURTH, T. 1976. Toward the wider use of tropical wood products. Unasylva 28:(112–113):119–126.

FOREST PRODUCTS LABORATORY. 1987. Wood handbook: Wood as an engineering material. Agric. Handb. 72. U.S. Department of Agriculture, Washington, DC. 466 pp.

GOVETT, R. L., K. A. BLATNER, AND W.-J. KIM. 1987. The Korean market: opportunities for American hardwood exporters. Forest Prod. J. 37(7/8):23–30.

HAGERTY, M. R. 1985. Improving the predictive power of conjoint analysis: The use of factor analysis and cluster analysis. J. Marketing Res. 22 (May):168–184.

HANSEN, B. G., AND ARAMAN, P. A. 1986. Hardwood blanks expand export opportunities. World Wood 27(1):34–36.

HAYGREEN, J. G., AND BOWYER, J. C. 1982. Forest products and wood science: An introduction. The Iowa State University Press, 495 pp.

INFOR-CORFO. 1989. Estadísticas Forestales 1988. Instituto Forestal-Corporación de Fomento de la Producción. Boletín Estadístico N 11. 115 pp.

INFOR-CONAF. 1989. Exportaciones Forestales Chilenas (Enero–Diciembre 1988). Instituto Forestal-Corporación Nacional Forestal. Boletín Estadístico N 9. 186 pp.

JÉLVEZ, A., K. A. BLATNER, AND R. L. GOVETT. 1989. The perceptions of Chilean exporters on potential market opportunities for solid wood products. 1989. Forest Prod J (Submitted).

JOHNSON, R. A., AND D. W. WICHERN. 1988. Applied multivariate statistical analysis. Prentice-Hall, Inc. Second Edition, 607 pp.

KLASTORIN, T. D. 1983. Assessing cluster analysis results. J. Marketing Res., 20 (February):92–98.

KLECKA, W. R. 1988. Discriminant analysis. series: Quantitative applications in the social sciences. Sage Publications, Ninth Printing. 71 pp.

PATTERSON, D. 1988. Commercial timbers of the world. Gower Technical Press. 5th ed., 338 pp.

PÉREZ, V. 1983. Manual de propiedades físicas y mecánicas de maderas chilenas. Documento de Trabajo N 47, CONAF/FAO, Santiago, 451 pp.

PLUMPTRE, R. A. 1972. Problems of increasing the intensity of utilization of tropical high forest. Commonwealth Forestry Rev. 51 (3):213–232.

PUNJ, G., AND D. W. STEWART. 1983. Cluster analysis in marketing research: Review and suggestions for application. J. Marketing Res. 20 (May):134–148.

SCHREUDER, G. F., AND R. P. VLOSKY. 1985. Indonesia forest products sector and trade profile. Working Paper N 4, CINTRAFOR, University of Washington, Seattle, WA.

STEWART, D. W. 1981. The application and misapplication of factor analysis in marketing research. J Marketing Res 18 (February):51–62.

TOWLER, R. W. 1975. The possibilities of increased consumption of the lesser-known tropical hardwood species. Commonwealth Forestry Rev. 54 (3/4):243–249.

ULLOA, F. 1984. Alcances sobre la disponibilidad de bosque nativo comercial en Chile. In: Proceedings of the XI Jornadas Forestales. Colegio de Ingenieros Forestales, 214 pp.

VINCENT, J. R., A. K. GANDAPUR, AND D. J. BROOKS. 1990. Species substitution and tropical log trade. Forest Science 36(3):657–664.