Long-Term Projections of Wood-Based Panel Consumption in Australia

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Long rotation times between plantation establishment and harvesting necessitate long-term projection models for forestry planning purposes. This study sets out the projection methodology and a range of five estimates for wood-based panels consumption based on realistic possibilities in dwelling commencements and panel usage per dwelling for 1990, 2000, 2010, 2020. A two-stage model was adopted. First, a relationship that not only explains the consumption of all wood-based panels but also is suitable for projection purposes is developed. Secondly, separate relationships were developed to project market shares of the individual panel products.

1. Introduction

In response to a resolution by the Australian Forestry Council in May, 1982, calling for a national wood production plan, the Bureau of Agricultural Economics produced long-term projections of the consumption of wood and wood products. This paper contains an outline of the methodology used in preparing these projections and the results of the projections themselves (*see* also Edquist and Morris 1985).

Wood-based panels used in Australia include particleboard, plywood, hardboard, softboard, veneer and medium-density fibreboard. Particleboard is sometimes known as 'chipboard' and is a panel consisting of relatively large particles that are glued together then pressed between heated platens. The type and quantity of adhesive used determines the strength and durability of the board. Veneer is a thin sheet of wood of uniform thickness, and is formed by either rotating a veneer log against a knife edge or by slicing the flitch. Plywood is the panel produced from assembling and bonding several veneers with the grain direction in one veneer at right angles to the adjacent veneers. Hardboard in Australia is known commercially as 'Masonite' and is a sheet material made from exploded eucalypt fibres felted together and consolidated under heat and pressure. Softboard is made from softwood fibres felted together but not consolidated under heat and pressure. Medium density fibreboard uses the softwood fibres and synthetic resin for adhesion. As the name suggests it has a density between that of hardboard and softboard.

Consumption of these wood-based panels in aggregate has expanded rapidly since the early 1960's (*see* Figure 1). The rate of growth in consumption of particleboard has been particularly rapid, averaging 16 per cent each year from 1963 to 1981. Growth in consumption of plywood is attributable principally to the introduction to the Australian market of structural and overlaid grades of plywood. Consumption of hardboard and softboard has been relatively stable. Medium-density fibreboard has only recently been introduced into the Australian market and, therefore, no indication of trends in its usage is available. However, the known attributes of medium-density fibreboard indicate that it could replace sawntimber in several end uses, and could also substitute for other wood-based panels.

Essentially the methodology for the projections consists of a two stage model. First, after consideration of the key demand factors, a relationship for all wood-based panels

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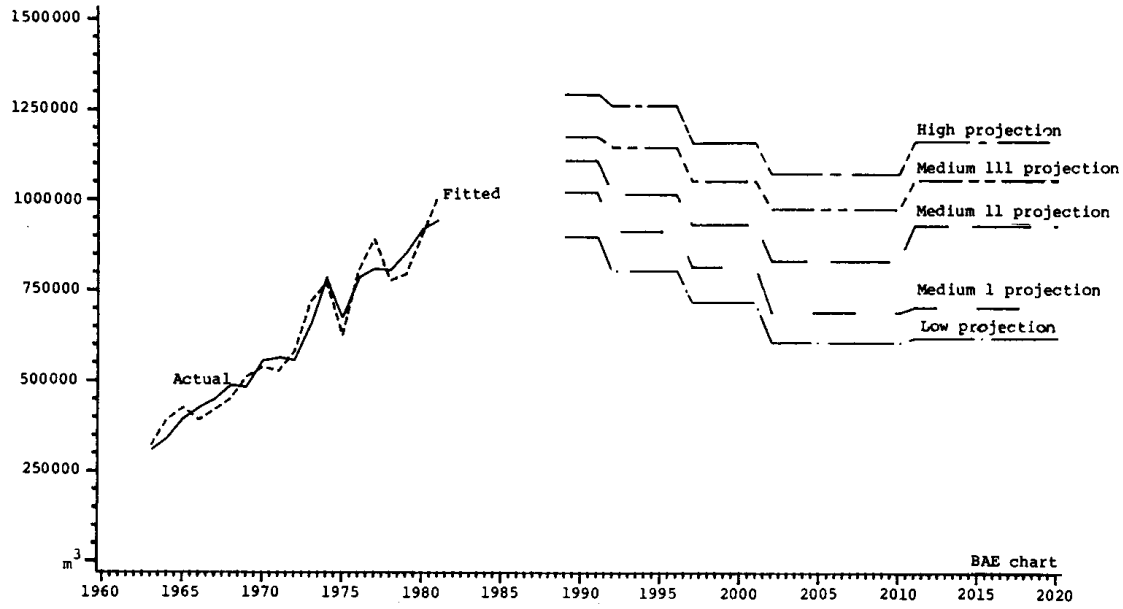

Figure 1: Projection of Aggregate Wood-Based Panel Consumption

consumption was specified. Secondly, separate relationships were developed to project market shares of individual panel products. Emphasis was placed throughout on selection of models and variables which were both explanatory and suitable for long term projections.

Projections of consumption are presented for 1990, 2000, 2010 and 2020, years for which projections of wood availability were compiled by the Forest Resources Committee (Australian Forestry Council 1981).

2. Previous Research

The main objective was to provide long-term projections of consumption. Lack of data, particularly on inventories, precluded the use of an econometric model of supply and demand for panel products for this purpose. As an alternative, a single-equation projection model was used. Such an approach has been used successfully elsewhere to analyse consumption data (B.A.E. 1984). Earlier studies of the wood-based panel market in Australia and overseas have typically modelled wood-based panel consumption as a function of population and gross domestic product. Only one Australian model has included a price variable (Ferguson 1979).

The approach taken by the Australian Forestry Council (1974) and subsequently by Treadwell (1978) was to use past trends in consumption per person for the panels sector in Australia in order to project future use. Both sets of resulting estimates for particleboard were considered too high by Ferguson and B.A.E. (1977).

Long-term projection models for Europe (F.A.O./U.N.E.C.E. 1976), based on pooled cross-sectional time series data, specified per person consumption against gross domestic product per person. This led to considerable overestimates of at least 34 per cent in actual consumption for 1980 (E.C.E. Timber Committee Secretariat 1980). Lyall (*see* Ferguson 1979) modelled particleboard consumption using a real price index and gross domestic product but problems were encountered with an insignificant and wrongly signed price coefficient.

3. Projection Model for the Aggregate Wood-Based Panel Sector and Empirical Results

3.1 Model specification

Wood-based panels have an extremely wide range of uses in furniture and joinery and

in the building and construction industries. Estimates by the State Forests Department Task Force, Victoria (1983) indicate that 71 per cent of particleboard marketed is used in furniture (fitted and free-standing) and 10 per cent in flooring. Given the current 66 per cent share of particleboard in the total wood-based panel market, these uses account for approximately half the aggregate wood-based panel market. Innovation in production and design has enabled panel products to capture a significant proportion of the market for sawntimber. In particular, plywood and the later development of veneered particleboard (veneered outermost layers on a particleboard core) have substituted for sawntimber in highly-priced furniture, built-in cupboards, panelling, shelving and flooring. Indicative of the degree of this substitution was the increase in the ratio of total panel consumption to the total number of dwelling commencements each year since 1962–63, from 3.5 m^3 in 1962–63 to 6.3 m^3 in 1980–81. Over the same period, the ratio of total apparent consumption of sawntimber to total dwelling commencements fell from 43 m^3 to 32 m^3 per dwelling.

All previous studies have failed to consider explicitly the effects of introducing technological change (particularly changes following the introduction of particleboard) and prices of panel substitutes. Given the rapid expansion in consumption of particleboard and the substitution of panel products for sawntimber, it was considered important that the selected model be specifically formulated to reflect both the adoption pattern of technological change and the prices of substitutes.

A logistic curve has been used successfully in other studies to reflect, empirically, the rate of adoption of new products and innovations (Jarvis 1981; Carmen 1982). This logistic curve is the mathematical formulation of the more familiar S-shaped curve. Many new products have exhibited this pattern of growth in their life-cycle (*see* Edquist and Morris (1985) for more information). Typically, consumption of a new product is initially low, increasing rapidly until the growth of new uses declines and the market share stabilises. Batten and Johansson (1984) have used this relationship between the logistic curve and the product life-cycle growth pattern to determine the stage of the product life-cycle for Swedish building materials including particleboard, plywood and veneer.

The consumption pattern, shape of the curve, as well as the duration and rate of adoption can all be estimated. In the light of all the above considerations, the following model, which makes use of the logistic curve, is used:

(1)

$$CD_t = S_L + (S_c - S_L)/(1 + \exp(-a - bT)),$$

where

CD_t = ratio of apparent consumption of wood-based panels to dwelling commencements in time t;

S_c = ceiling of the ratio of wood-based panel consumption to dwelling commencements;

S_L = lowest level of the ratio of wood-based panel consumption to dwelling commencements;

a = constant;

b = rate of adoption of a product; and,

T = time where 1962–63 = 1.

S_c and S_L are the upper and lower bounds, respectively, for the adoption of the new product and are estimated as parameters in the modelling process.

This model is a simple version of the logistic model. Adoption of wood-based panels is assumed to proceed through time, as one influence along with others such as changes in prices, income and other factors. An alternative model, based on model (1) but incorporating the relative prices of wood-based panels to sawntimbers, income and time, as a proxy for changes in consumer preference, is as follows:

(2)

$$CD_t = S_L + (S_c - S_L)\,(a_1 + a_1 PR_t - a_2 \mathrm{T})/ (1 + \exp(-a_2 - b_1 T - b_2 y_t T - b_3 PR_t T)),$$

where the additional variables are:

PR_t = ratio of wood-based panel prices to sawn timber prices;

Y_t = real gross domestic product per person; and,

a_1, a_2, a_1, a_2, b_1, b_2, b_3 are constants to be estimated.

These additional variables are assumed to affect the upper bound of consumption and the rate of adoption of the product.

3.2 Empirical results

Equation (2) was estimated using a non-linear least squares procedure (*see* Eisenpress and Greenstadt 1966). This procedure estimates all the parameters set out in Table 2. Price and income effects were incorporated into the model specification in the various ways outlined in equation (2). On testing the relationships, a number of statistical difficulties were encountered. During the limited period for which the equation could be estimated using the price variable, there was very little variation in the ratio of the quoted price of plywood to that of sawntimber. The variation about the mean was five per cent and its growth rate was zero. As a result, it was not possible to obtain precise estimates of the coefficients on the price variables. A high correlation between the time and income variables in the denominator resulted in a similar problem. In other words, it was not possible, given the sample, to disentangle the separate effects of the economic variables on consumption. Therefore, the preferred model for projection purposes was equation (1). Annual data over the period 1962-63 to 1980-81 (data sources are set out in the Appendix) were used and the estimated parameters are presented in Table 2. Estimation of the model was restricted to 1980-81 because veneer consumption data was not available after that date. Figure 1 illustrates the close fit between the actual data and the consumption estimates derived from the model.

The exclusion of the price ratio from the forecasting equation will have little effect on the projections if there is little movement in the relative price of panels and sawn timber over the projection period. Comparison of the installed costs of flooring (includes total costs of flooring and sub-floor frame) of panels to concrete and sawn timber from 1978 to 1984 show very little change (Cordell Building Publications 1984). Similarly there were only marginal changes in the price relativities between plasterboard to veneered particleboard wall linings and plasterboard to plywood wall linings from 1974 to 1983 (Australian Institute of Quantity Surveyors 1984). At present, there is no evidence to suggest that the relative prices used in equation (2) will change substantially in the future.

The increasing ratio of consumption of wood-based panels to dwelling commencements is estimated by the non-linear estimation procedure to firm at a ceiling of 6.8 m^3 per dwelling by 2005–06. This result conforms closely with expert industry opinion that the period of high growth for most panels is nearly ending. According to these industry sources fewer new end-uses for the panels are identifiable, substitutes are occurring in the traditional particleboard markets and technological advances in this area appear to be levelling off. Additionally, this ceiling level was confirmed by a re-estimation of the model using independent estimates for veneer consumption from 1981–82 to 1983–84. However, these data points , while providing additional evidence to support the model chosen, had to be excluded from the analytical model because to do so introduces estimation bias. Finally, short-term fluctuations about this level could occur should changes occur in such factors as relative prices between panels and their substitutes, house sizes including alterations and additions and household size. As noted, changes in these relativities appear to be unlikely over the projection period.

3.3 Projected consumption of aggregate wood-based panels

To overcome the difficulty in selecting assumptions that will hold throughout the forty-year projection period, a sensitivity analysis based on plausible options was undertaken. This resulted in a range of five longer-term estimates.

Over time, a permanent increase or decrease in the ceiling level may occur. For example, future trends towards smaller houses and smaller average size of households (Roseth 1983) are likely to result in reduced floor areas, and lower, rather than higher, built-in furniture requirements and therefore lower panel usage. It is conceivable that, with a 4 per cent reduction per annum in house size, the wood-based panel consumption per dwelling commencement ratio could fall. Another factor that could lead to a lower ceiling limit is substitution of thin for thick panels due to changing price relativities. The best overall judgment of the combined effect of these factors is a drop in consumption per dwelling of about 10 per cent. Alternatively, a high ceiling of total wood-based panel consumption to dwelling commencements could occur with greater penetration of panels into the flooring market and as a result of increased activity in the housing alterations market. For example, if an extra 30 per cent of new houses installed

panel flooring, average consumption per dwelling would increase by at least 0.5 m^3. Overall, taking these factors into consideration, it seems unlikely that consumption per dwelling will rise by more than around 10 per cent over the projection period. The above sensitivity levels of approximately plus or minus 10 per cent, correspond closely to the 95 per cent confidence limits associated with the mean estimate of 6.8 m^3 per dwelling derived from equation (1). Therefore, these confidence limits, corresponding to a low ceiling of 6.0 m^3 per dwelling and a high of 7.5 m^3 per dwelling, are used as bounds in the consumption projections (*see* Figure 2).

Total apparent consumption of wood-based panels was then projected using equation (1) and three series of dwelling requirement projections for the period 1984–2001 published by the Indicative Planning Council for the Housing Industry (1984, series B, C and D). Because of the unavailability of published forecasts to the year 2020, these were projected by using a linear regression model of dwellings against population projections to the year 2020. These population projections were based on annual migration levels similar to those estimated by the Australian Bureau of Statistics (1982*e*, p. 26, series B and D), namely 75 000 and 125 000 persons. Constant socioeconomic trends in household formation were assumed. To take into account any error introduced by adopting the Indicative Planning Council for the Housing Industry's projections, three series, high, medium and low were utilized.

The projected dwelling requirements are predicated on a sustained recovery in the building and construction industry. It follows that the projected rapid increase in wood-based panel consumption also depends on that recovery.

The long-term underlying housing projections are only available from 1988 onwards. Medium-term (1984–1987) estimates have not been made as these projections would not be directly comparable to the long-term housing requirement projections used here.

The five projections of consumption of all wood-based panels are illustrated in Figure 1 and set out in Table 1. The low projection corresponds to the low-ceiling limit associated with the low level of dwelling requirements, Series B. The medium I, II and III projections result from simulating equation (1) with the three selected dwelling requirement projections B, C and D, respectively. The high projection assumes the high ceiling estimate together with a high level of dwelling requirements, Series D.

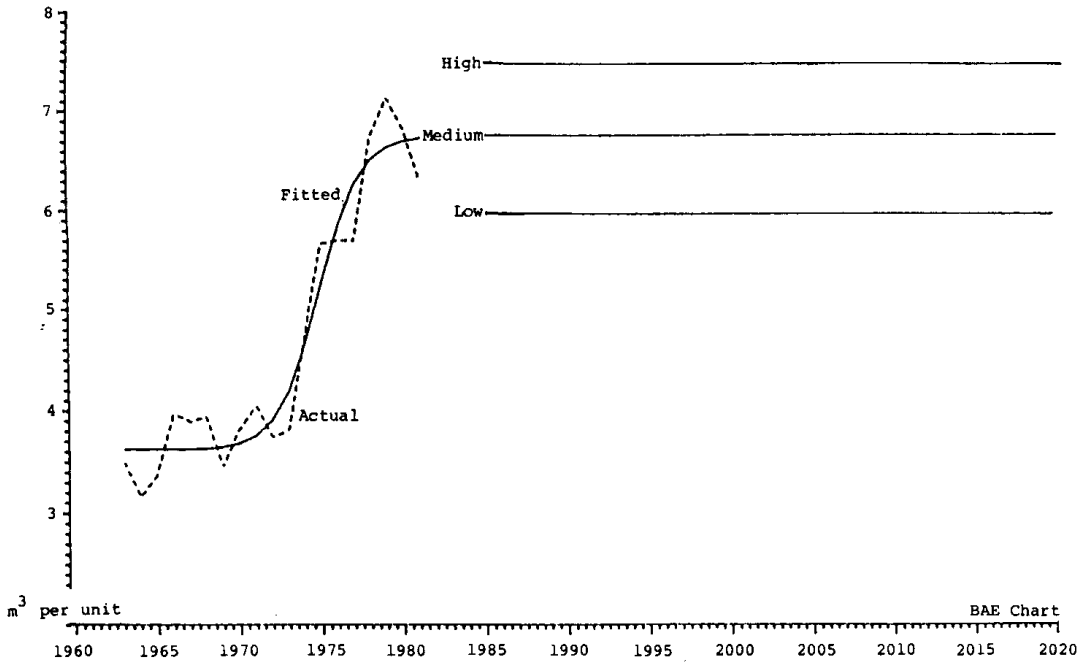

Figure 2: Ratio of Aggregate Wood-Based Consumption to Dwelling Commencement

In 1979–80, consumption of all wood-based panels per thousand persons was 57 m^3. This is projected to be between 53 m^3 and 74 m^3 per thousand persons in 1990, and then, in line with decreasing housing requirements, estimated to fall by 2020 to between 27 m^3 and 45 m^3 per thousand persons.

These results, taken in conjunction with the earlier rapid growth in wood-based panel consumption, illustrate the performance of a new product or new technology, which captures new end uses until these are exhausted. The product then enters the mature marketing phase. The decline in projected consumption levels at that stage and thereafter reflects reduced levels of dwelling requirements, resulting from an ageing population base.

Table 1: Projections of Consumption of all Wood-Based Panels

Estimate	1990	2000	2010	2020
	Total (million m^3)			
Low (*a*)	0.90	0.72	0.61	0.62
Medium I (*b*)	1.02	0.81	0.69	0.70
Medium II (*b*)	1.11	0.93	0.83	0.93
Medium III (*b*)	1.17	1.05	0.97	1.05
High (*c*)	1.29	1.16	1.07	1.16
	m^3 per thousand of population			
Low (*a*)	53	37	29	27
Medium I (*b*)	60	42	33	30
Medium II (*b*)	64	46	36	36
Medium III (*b*)	67	52	42	41
High (*c*)	74	57	47	45

(a) Estimated using the low ceiling and the low forecast of dwelling requirements.
(*b*) Estimated using the medium ceiling and the low, medium and high forecasts of dwelling requirements respectively.
(*c*) Estimated using the high ceiling and the high forecast of dwelling requirements.

Finally, these projections would need to be revised in line with the new information, if trends in gross domestic product or wood-based panel and sawn-timber prices change significantly, or should dwelling requirements and/or the ratio of wood-based consumption per dwelling commencement not fall within the projected ranges.

4. Projection Models for Market Shares of Individual Panel Types and Empirical Results

4.1 Particleboard and medium-density fibreboard

Particleboard dominates the wood-based panels market in Australia. Its usage has expanded most rapidly of all products over the period 1962–63 to 1980–81. Given the close substitutability of medium-density fibreboard for particleboard demonstrated in the United States (Deppe 1980), it was considered appropriate to project an aggregate market share for the two products.

Particleboard and medium-density fibreboard are the newest panels in the Australian wood-based panels sector. This fact means that the specification of a market share and consumption model must reflect the pattern of various phases of market development over time. A logistic curve was considered appropriate and statistical tests showed an excellent fit with actual consumption data. Non-linear estimates of the coefficients are included in Table 2 and the projected market share for particleboard and medium-density fibreboard is presented in Table 3. In this model the lower bound of the market share was set to zero, reflecting the more recent introduction of these products on the market compared with the rest of the wood-based panels.

The market share for particleboard and medium-density fibreboard is projected to continue increasing asymptotically and to reach 68 per cent by the year 2020. This trend approximates the high consumption growth of particleboard and medium-density fibreboard and its levelling off as mature marketing development is approached.

4.2 Plywood

The share of plywood in the consumption of all wood-based panels declined over the period 1965–66 to 1980–81. However, over the same period, the plywood share of the residual market (that is, total wood-based panels excluding particleboard and medium-density fibreboard) was found to have increased in a logistic trend.

Nonlinear estimates of the coefficients are presented in Table 2. Using the resultant relationship, the market shares for plywood will stabilize at around 51 per cent of the residual market from 1990 onward. This trend correlates with a 17 per cent market share for plywood in the total wood-based panel market (*see* Table 3).

4.3 Veneer, hardboard and softboard

The share of veneer in the total wood-based panel market has been static since 1968–69, at five per cent. There is no reason to expect that this share will not be maintained until 2020 (*see* Table 3), as veneer is likely to remain a decorative cover for residue-based panels.

The hardboard share of the total wood-based panel market has steadily declined, from 32 per cent in 1965–66 to ten per cent in 1980–81. However, its share of the total hardboard and softboard market (that is, the residual market at this stage of the analysis) has fluctuated at around 83 per cent, with only minor variations, since 1971–72. For projection purposes, hardboard was assumed to occupy a constant share of this residual market equal to the past average of 83 per cent. The hardboard share of the total wood-based panel market is projected to be eight per cent in 2020 (*see* Table 3).

Similarly, the share of softboard consumption in the hardboard and softboard market was estimated at a constant 17 per cent. This resulted in a projected market share in the total wood-based panel market of two per cent from 1990 to 2020, a reasonable figure given the decline to that level which had occurred by 1980–81 (*see* Table 3).

Table 2: All Wood-Based Consumption Model and Market Share Models

Panel Types	*Nonlinear Estimates of the Parameters(a)*				
	R^2	S_L	S_c	b	a
All wood-based panel consumption	0.94	3.6 (31.9)	6.8 (11.8)	0.8 (3.7)	−10.2 (3.9)
Particleboard and medium-density fibreboard(*b*)	0.98	0	0.68 (29.2)	0.2 (10.5)	−1.4 (14.4)
Plywood(*c*)	0.89	0	0.52 (30.1)	0.2 (4.4)	0.5 (5.2)

(*a*) Refer to equation (1) for specification of parameters. (*b*) Share of particleboard plus medium-density fibreboard in total wood-based panel market. (*c*) Plywood consumption as a proportion of consumption of all wood-based panels, less particleboard and medium-density fibreboard.
Note: Figures in parentheses are asymptotic t values.

Table 3: Actual and Projected Shares of Consumption of Individual Wood-Based Panel Types

Panel Types	1969–70	1980–81	1990	2000	2010	2020
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Particleboard and medium-density fibreboard	42	66	68	68	68	68
Plywood	26	17	17	17	17	17
Veneer	5	5	5	5	5	5
Hardboard	22	10	8	8	8	8
Softwood	5	2	2	2	2	2
Total	100	100	100	100	100	100

Sources: Australian Bureau of Statistics (1982*c*); Department of Primary Industry (1982).

4.4 Projected consumption of individual panel types

The projected consumption of wood-based panel types was estimated by applying the estimated market shares for each panel to the projections of consumption of all wood-based panels (*see* Table 4). As with the consumption projections for aggregate wood-based panels, the range of consumption projections for individual types of panel shows an initial increase to 1990 and then a decline to 2010, in line with the pattern of housing requirements. An increase in consumption then occurs between 2010 and 2020. The most significant projected increase in consumption is that of particleboard and medium-density fibreboard. Consumption (0.6 million m^3 in 1980–81) is projected to be between 0.6 million m^3 and 0.9 million m^3 in the year 1990, and between 0.4 million m^3 and 0.8 million m^3 in 2020 (*see* Table 4 and Figure 3).

Plywood, veneer and softboard consumption levels are projected to increase from 1979–80 levels and follow the same trend as particleboard and medium-density fibreboard consumption. Hardboard consumption (93 000 m^3 in 1980–81), is projected to be between 78 000 m^3 and 112 000 m^3 in 1990, then to follow the trend in the consumption of the other panels.

5. Future Developments

Recognizing that these projections are dependent on the modelling process and the associated assumptions and uncertainties in them, they should not be construed as actual forecasts but rather as indicators of the underlying trend. This trend indicates that no dramatic increases in total manufacturing capacity (currently in excess of required levels) and its necessary inputs such as labour and raw materials, are likely to be needed in the longer term.

The market size and shares of the individual wood-based panels, as outlined above, depend on a continuing slow rate of change in building technology. Future developments in both the product and its end-use industries will, however, bring about some change in both demand and supply of wood-based panels. Such developments will include the production of stronger, cheaper boards of consistent quality from a wider variety of species than those currently utilized. This is evidenced by the range of new reconstituted boards using new technologies that are currently being developed or manufactured overseas, including oriented structural boards and waferboards. Production of boards by combining different panels (Vesihiisi 1980) or by combining hardwood and softwood plywood

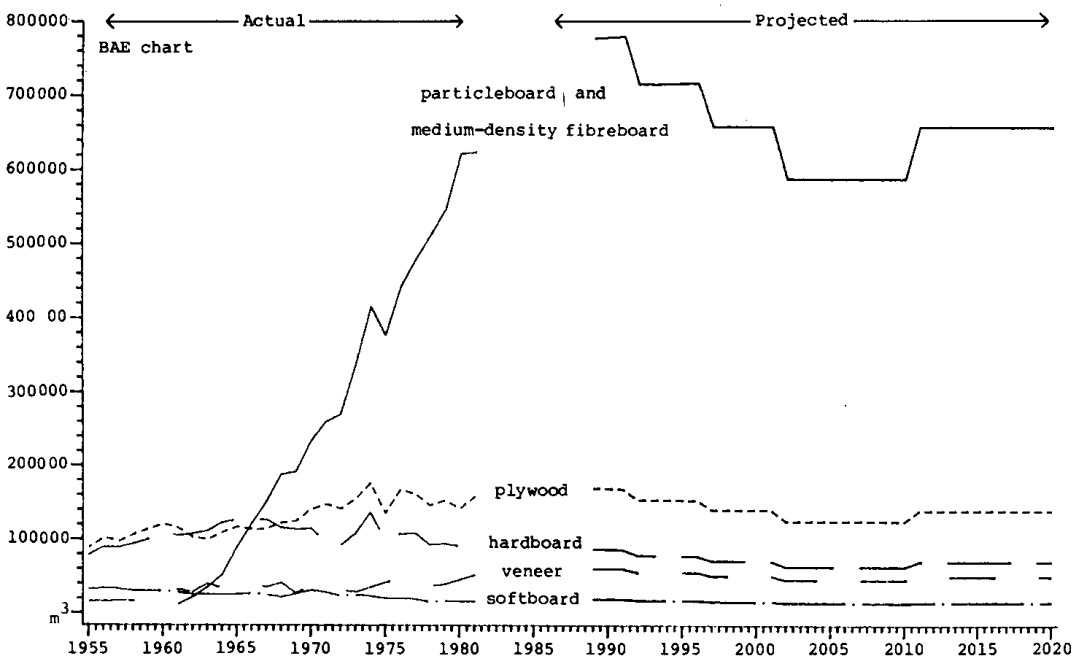

Figure 3: Projections of Wood-Based Panel Consumption by Types

Table 4: Projections of consumption of individual wood-based panel types

Panel Type	1990	2000	2010	2020
	'000 m^3	'000 m^3	'000 m^3	'000 m^3
Particleboard and medium-density fibreboard—				
low (*a*)	609	487	412	422
medium II (*b*)	749	632	563	632
high (*c*)	876	787	730	791
Plywood—				
low	149	118	100	103
medium II	184	154	137	154
high	215	191	177	192
Veneer—				
low	48	38	32	33
medium II	58	49	44	49
high	69	61	57	62
Hardboard—				
low	78	60	51	52
medium II	96	78	70	78
high	112	98	90	98
Softboard—				
low	16	12	10	11
medium II	20	16	14	16
high	23	20	18	20

(*a*), (*b*), (*c*) see footnotes to Table 1.

(Lyngcoln 1982) is also possible. Decreasing the costs of glue has been a continuing aim and research in Australia continues to seek methods for using hitherto underutilized species (Lyngcoln 1982).

Once developed, any new board could find new applications and/or substitute for other panels in much the same manner that particleboard and medium-density fibreboard have done. This could mean a consequent reduction in the market share of at least one of the other wood-based panels. However, should significant additional end uses be captured by any panel product, total consumption levels of all wood-based panels would increase beyond those projected.

A further prospect is the increased supply of imported boards. If these boards were cheaper and their sales were directed to current end uses, then aggregate consumption (which is not particularly responsive to price) might not change greatly and a fall in domestic production of panel products might result. However, if increased supplies of wood-based panels (in particular plywood) were to result in expansion in end uses of panel products, then the aggregate market for wood-based panels in Australia might increase, with uncertain implications for the level of domestic production.

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Appendix

Data Sources

Item	Source
Apparent consumption—	Department of Primary Industry (1982).
• particleboard	Table 29.
• plywood	Table 24.
• veneer	Personal communication (*a*).
• hardboard	Table 33.
• softboard	Table 34.
Imports—	
• medium-density fibreboard	Australian Bureau of Statistics (1982*d*).
Gross domestic product—	
• constant 1979–80 prices	Australian Bureau of Statistics (1982*b*).
Population—	
• as at 30 June	Australian Bureau of Statistics (1982*a*).
Prices—	
• particleboard	Australian Bureau of Statistics (1982*c*).
• plywood	Australian Bureau of Statistics (1982*c*).
• sawntimber	Australian Bureau of Statistics (1982*c*).

(*a*) I. Chaplin, Department of Primary Industry, personal communication, February, 1983.