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Preliminary long-term forecasts of wood product demand in Australia

Mihir Gupta, Kristen Corrie, Beau Hug and Kevin Burns

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Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
Postal address GPO Box 1563 Canberra ACT 2601
Switchboard +61 2 6272 2010
Facsimile +61 2 6272 2001
Email info.abares@daff.gov.au
Web daff.gov.au/abares

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Summary

The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has estimated domestic wood product consumption and trade over the forecast period from 2011–12 to 2049–50, using a set of assumptions defining a business-as-usual outlook scenario. This scenario describes the outlook for various parameters affecting the forestry sector, assuming maintenance of existing trends and government policies. The objective of this report is to document the methodology and assumptions underlying the ABARES estimates of preliminary forecasts of consumption and imports of sawnwood, wood-based panels and paper and paperboard products and exports of woodchips. The preliminary long-term forecasts in this report are contingent on the combination of data and assumptions employed. These assumptions do not take into account substitution between wood products and non-wood products such as brick and steel. Nonetheless, the forecasts in this report are the best estimates, given the assumptions listed; they provide an outlook for long-term demand for these products, and will guide future research in investigating potential log availability, domestic processing capacity and subsequent production.

This report is an update of previous research ABARES undertook in 1989 (Hossain et al. 1989) and 1999 (Love et al. 1999). While past reports presented forecasts for wood product consumption, ABARES has additionally modelled imports of wood products and exports of woodchips in this report. Some of the challenges previous research faced have also been addressed, particularly an extensive update to the methodology behind consumption forecasts.

The focus in this report is to fit econometric models that provide the best possible estimate for the relationship between demand and factors driving the demand for sawnwood, wood-based panels and paper and paperboard as aggregated commodity groups. Price information was considered but not used due to lack of reliable and time-consistent data. The fitted models when backcast and compared with actual data showed that actual data is consistently within the 95 per cent confidence intervals (which approximately represents two standard errors above and below model estimates) and is closely followed by model estimates. The models largely captured directional movements in actual data and rigorous testing shows their reliability in forecasting under the assumptions made for the business-as-usual outlook scenario. Factors driving production and exports for these commodity groups differ; ABARES may address these in future research. Forecasts for exports of woodchips have been prepared under two scenarios that outline potential domestic environments for paper and paperboard and wood-based panel production.

Historically, ABARES calculated wood products consumption using the apparent consumption method, which adds production and imports and subtracts exports to derive a proxy for consumption. As a result, forecasts using consumption models reflect the apparent consumption estimate. Ninety-five per cent confidence intervals were constructed to provide a range for these forecasts with 95 per cent certainty under the business-as-usual assumptions. The potential projected range in the future would be far wider given the potential for exogenous variables to be different than assumed. In the long term, such as the 39-year time horizon examined in this report, all variables and drivers are subject to change. For example, the material properties of the products, the availability of substitutes and consumer preferences and perceptions may change, all of which would alter the relationship between variables over time.

ABARES preliminary forecasts indicate that sawnwood consumption will continue to increase to 2049–50, albeit more slowly than consumption of other wood products, driven by ongoing

growth in detached and multi-dwelling commencements, underpinned by Australia's population growth. Sawnwood consumption is forecast to increase from 5.0 million cubic metres in 2010–11 to 6 million cubic metres in 2029–30 and 6.5 million cubic metres in 2049–50. While sawnwood consumption in Australia declined by an average of 0.5 per cent a year between 2000–01 and 2010–11, it is forecast to grow by 0.7 per cent a year on average between 2011–12 and 2049–50. Sawnwood imports are also forecast to increase, growing by 1.5 per cent a year on average between 2011–12 and 2049–50. This is driven by an assumed rise in multi-dwelling commencements. Sawnwood consumption per capita falls over the forecast period and the proportion of sawnwood imports to consumption rises, averaging 22.4 per cent between 2044–45 and 2048–49.

ABARES estimates that wood-based panel consumption will continue to increase over the forecast period, driven by growth in multi-dwelling commencements and alterations and additions, both of which are underpinned by population growth in capital cities. Consumption of wood-based panels is forecast to increase by an average of 2 per cent a year, from 2 million cubic metres in 2010–11 to 3.1 million cubic metres in 2029–30 and 4.3 million cubic metres in 2049–50. This is lower than historical growth in consumption, which grew by 3.6 per cent a year on average between 2000–01 and 2010–11. Wood-based panel imports are forecast to grow at a slower rate, averaging 0.8 per cent a year between 2010–11 and 2049–50. Wood-based panel consumption per capita rises over the forecast period and the proportion of imports to consumption falls averaging around 12.4 per cent between 2044–45 and 2048–49.

Paper and paperboard consumption is forecast to grow at a slower rate than imports. ABARES estimates that paper and paperboard consumption will increase from 4 million tonnes in 2010–11 to 5.8 million tonnes in 2029–30 (averaging 1.9 per cent a year between 2010–11 and 2029–30) and reaching 7.1 million tonnes in 2049–50 (averaging 1 per cent a year between 2029–30 and 2049–50). These forecasts are based largely on ABARES projections for value adding by the manufacturing sector. The manufacturing sector is a large user of packaging and industrial paper and printing and writing paper and represents a domestic demand factor. Growth in paper and paperboard imports is expected to increase marginally from around 2 per cent a year between 2000–01 and 2010–11 to an average of 2.2 per cent a year between 2010–11 and 2049–50. Paper and paperboard consumption per capita rises over the forecast period and the proportion of paper imports to consumption rises averaging around 59.8 per cent between 2044–45 and 2048–49.

Consumption per capita may be used as an indicator for long-term forecasts of wood products demand. A stronger growth in consumption of a wood product than in population suggests an increase in use, and demand for, that product. The results imply an increased demand for wood-based panel and paper and paperboard products. In contrast, while consumption of sawnwood is forecast to increase, consumption per capita is estimated to decrease. These results are based on the population growth path assumed in *Strong Growth, Low Pollution* (Australian Government 2011).

A substantial share of Australia's current wood processing capacity includes woodchip production for export. Forecasts of pulplog availability have been compiled from ABARES publicly available datasets. Based on the estimated growth in pulplog availability, additional domestic infrastructure capacity may be needed for these logs. This investment may result in capacity to process domestically or additional exports of unprocessed logs and woodchips following recent trends in domestic woodchip production. For example, the volume of plantation pulplogs harvested from hardwood forests for woodchip exports has increased by around 31 per cent from 3.6 million cubic metres in 2006–07 to 4.7 million cubic metres in 2010–11. A scenario considered to be an upper bound is examined in this report by assuming constant domestic production of paper and paperboard and wood-based panels (that is, no further investment in capacity to process logs domestically). Under this scenario, woodchip exports are forecast to increase from 5.1 million cubic metres in 2010–11 to 6.5 million cubic metres in 2029–30 (averaging a 1.5 per cent increase per year between 2010–11 and 2029–30) and remain stable thereafter to around 6.5 million cubic metres in 2049–50 (averaging a zero increase per year between 2029–30 and 2049–50). This trend in woodchip exports is primarily driven by the forecast increase in availability and harvest of pulplogs.

An alternative scenario is investigated by assuming constant exports of paper and panel products which allows estimation of domestic production as the gap between forecast consumption and imports. This scenario assumes there is scope for new investment in additional paper and paperboard processing and wood-based panel manufacturing capacity in Australia. Under this scenario, woodchip exports are forecast to increase from 5.1 million cubic metres in 2010–11 to 5.8 million cubic metres in 2029–30 (averaging a 0.9 per cent increase per year between 2010–11 and 2029–30) and decrease to 5.2 million cubic metres in 2049–50 (averaging a 0.5 per cent decline each year between 2030–31 and 2049–50). The trend in woodchip exports is driven by the forecast for total pulplogs harvested and influenced by the volume of pulplogs used for domestic production of paper and panels. Woodchip exports are forecast to fall between 2029–30 and 2049–50 due to growth in consumption of wood-based panels and a decrease in the proportion of imports to consumption. This combined with steady growth in paper and paperboard consumption results in higher domestic panel and paper production and consequently higher domestic demand for pulplogs during a period where pulplogs available for harvest are projected to decrease.

These findings raise important questions about the potential for more investment in domestic processing capacity and/or investment in export facilities thereby exporting raw materials (such as logs and woodchips) overseas for processing and importing finished products for domestic consumption. While this report does not assess the potential for domestic processing of Australia's forecast log availability, future analysis could investigate such areas. The log availability forecasts are based on the assumption that harvested areas will be replanted with the same type of plantation species. The forecasts do not take into account any future management decisions such as plantations with low growth rates not being replanted and converted to another land use. As information becomes available, the forecasts may be revised to reflect these changes in subsequent reports. The extent to which investment will be undertaken in Australia to facilitate processing of the forecast increase in log availability will depend on a number of factors, particularly the economic competitiveness of domestic processing and capital costs.

The models and forecasts developed as part of this project will provide key inputs that enable such analysis using the ABARES Forest Resource Use Model (FORUM) to investigate investment and production decisions over time. An integrated approach, that incorporates consumption and import econometric models, would explore the log equivalent consumption implied by the forecasts presented in this report. Further, combined with the outputs of FORUM, a comparison with projections for availability of different sawlog and pulplog grades would provide insights to trends in production of different wood products. Such analysis would also provide a better understanding of trade flows and the importance of trade.

1 Introduction

Forest and Wood Products Australia (FWPA) and the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) jointly funded this report to improve the quality and scope of wood products forecasts and inform the future of the Australian forestry sector.

This report updates Love and colleagues (1999), and provides long-term forecasts of wood products consumption and trade in Australia. The modelling framework was revised to address some challenges previous approaches faced. The ramifications of a range of variables on consumption and trade of wood products were considered and analysed using econometric models. Extensive testing of model stability, forecasting capability and drivers of forecasts are also discussed. The full potential of constructed models lies in forecasting consumption and trade of wood products to 2049–50 thereby providing an estimate of demand for such products.

The objective of this report is to document the methodology and assumptions underlying ABARES estimates of preliminary forecasts of the consumption and imports of sawnwood, wood-based panels and paper and paperboard products and exports of woodchips. The preliminary long-term forecasts in this report are contingent on the combination of data and assumptions employed. These assumptions do not take into account substitution between wood products and non-wood products such as brick and steel. Nonetheless, the forecasts are the best estimates given the assumptions listed, providing an outlook for long-term demand for these products and guides future research in investigating log availability, domestic processing capacity and subsequent production.

This report presents the methodology and forecasts for ABARES analysis of wood product demand (consumption and imports) in Australia under a business-as-usual outlook scenario. The analysis focused on construction of key datasets and development of forecasting methodologies to forecast consumption and imports of major wood products in Australia to 2049–50.

The report provides a description of the consumption and import forecasts for sawnwood, wood-based panels and paper and paperboard, as well as woodchip exports. A summary of the methodologies, datasets and assumptions employed in the analysis are also presented. Production and export forecasts have not been prepared in this report although estimation of these parameters could be undertaken in future research using the ABARES Forest Resource Use Model (FORUM). Forecasts for exports of woodchips have been prepared under two scenarios that outline potential domestic environments for paper and paperboard and wood-based panel production. Forecasts of pulplog availability have been compiled from ABARES published datasets (ABARES 2012; Gavran et al. 2012) and updated based on anecdotal information from industry. The forecasts are based on the assumption that harvested areas will be replanted with the same type of plantation species. The forecasts do not take into account any future management decisions such as plantations with low growth rates not being replanted and converted to another land use. As information becomes available, the forecasts may be revised to reflect these changes. The appendixes provide greater detail about the methodologies and assumptions used for specific models and forecasts.

2 The modelling approach

In this report, forecasts were presented for aggregated products, namely sawnwood, wood-based panels, paper and paperboard and woodchips. These products represent the major wood products consumed and traded in Australia. Given the focus of this report is to present estimates for long-term demand for wood products, the econometric models were constructed on a primary demand variable and other macroeconomic variables likely to affect the volume of consumption and imports. The forecasts were then based on assumptions for these inputs within a business-as-usual scenario.

The models for consumption and imports were constructed independently of each other and did not account for the definition of apparent consumption when forecasting. Hence it is not possible to make any inferences for domestic production and exports.

The models were estimated using the econometric and forecasting software, EViews.

Outlook scenario: business-as-usual

Considerable uncertainties surround the outlook for many economic parameters which are essential to forecasting wood product demand. The economic parameters that contribute to future trends in the forestry sector include growth in gross domestic product (GDP), population growth rates, rates of housing formation, and substitution of wood products in final demand. Other factors relating to government policies (such as native forest regulations) and the pricing of environmental externalities (such as greenhouse gas emissions and carbon sequestration) will also affect the forestry sector.

For this analysis, ABARES assumed business-as-usual parameters over the outlook period, from 2011–12 to 2049–50. The assumptions for these parameters are described in Table 1. While many business-as-usual assumptions may seem restrictive, they are intended to benchmark the forestry sector to current resource, technology and market parameters, which can then be compared against different assumptions in alternative outlook scenarios in future research. It is important to recognise that the outlook for business-as-usual forecasts is based on the best available data and current government policy settings; hence, forecasts do not include potential future changes to government policies that affect the forestry sector.

The business-as-usual scenario is based on previous research (including Australian Government 2011 and de Fégely et al. 2006), updated with more recent data and trends in the forestry sector. Table 1 presents the key parameters employed in the forecasts presented in this report. The values of these parameters are described in the key datasets section. More detailed description of the datasets used in this report is also provided in Appendix B.

Changes to markets will also have a significant bearing on the outlook for the domestic forestry sector and particularly on demand for wood products. For this report, ABARES used estimates of economic growth based on projections from the Global Trade and Environment Model (GTEM), ABARES projections for value added by the manufacturing sector and Australia's population growth prepared by the Australian Government (2011).

ABARES estimated or assumed other key market datasets. For instance, interest rates are assumed to converge to long-term averages and exchange rates are assumed to converge to parity. Using historical trends, ABARES estimated the number of new housing commencements, the share of detached and multi-dwellings and the real value of spending on alterations and additions. The specific assumptions and methods used in developing these parameters are described in Appendix B.

Table 1 Key parameters employed in business-as-usual scenario

Parameter	Description	Business-as-usual assumption
Forest resource a		
Pulplog availability from native and plantation forests	By region; area and management regime	No change to existing areas or management policies affecting pulplog availability
Markets b		
Australian economic growth	Growth in real GDP and manufacturing output to 2049–50	Australian Government (2011) forecasts
International economic growth	Growth in real GDP in principal wood product export markets	Australian Government (2011) forecasts
Wood product prices	Real prices for imports, exports and the domestic market for wood products	No change
Population growth rate	National	Australian Government (2011) forecasts
Interest rate	Domestic Australian lending rates	ABARES estimate of long-term average
Exchange rate	Australian to US dollar	ABARES assumption for long-term parity
Discount rate	Weight used to convert future dollar value to current dollars	Australian Government (2010) assumption
Housing sector activity	National, number of new dwellings commenced per annum	ABARES estimate of long-term trend
Type of housing sector activity	Ratio of multi-residential to total dwellings commenced	ABARES estimate of long-term trend
Timber used in housing	Change in timber use per detached and multi-residential dwelling	No change from current timber use
Alterations and additions activity	Real value spent on alterations and additions in housing	ABARES estimate of long-term trend
Global wood product market trends	Changes to international demand and supply of wood products	ABARES estimate of long-term trend

Note: **a** Forest resource business-as-usual assumptions are based on the methodology outlined in ABARES (2012) and Gavran and colleagues (2012) as well as anecdotal information from industry; **b** Business-as-usual forecasts for market parameters are discussed in detail in Appendix B.

In addition to the key parameters in Table 1, a range of other factors may affect the forestry sector. International supply and demand factors, and changes to other sectors of the Australian economy, may influence domestic prices, production, consumption and trade. For example, de Fégely and colleagues (2006) provided a number of additional assumptions that may affect the future of the forestry sector, including labour supply and energy costs. Some of these parameters are included in Table 1. While they have not all been incorporated in the business-as-usual scenario, some could be employed in future research around sensitivity analysis or incorporated in a future alternative scenario analysis.

ABARES tested the sensitivity of consumption forecasts to key underlying explanatory variables (variables that help describe and explain consumption) by examining high and low scenarios for the estimated or assumed market datasets—detached and multi-dwelling commencements and value added by the manufacturing sector. ABARES projections for these variables are based on historical trends and are subject to considerable uncertainty. To account for this uncertainty, additional analysis was undertaken for consumption models to demonstrate how changes to these key demand variables in the future would change the corresponding forecast for consumption. This relationship is described by the coefficients in the model that estimate the sensitivity of the forecasts to changes in the explanatory variables. As these models are constructed in first difference logs, the coefficients approximate a percentage change. For example, if the coefficient of an explanatory variable has a value of ‘β’, then for a 1 per cent change in the explanatory variable consumption changes by ‘β’ per cent.

Drivers of consumption and trade

Structural timber

Consumption of structural timber is hypothesised to primarily be a function of housing starts and other macroeconomic variables. Given that a significant percentage of sawnwood and wood-based panel consumption is used for structural purposes, detached and multi-dwelling housing commencements and alterations or additions to existing homes (or renovations) are likely to be the major demand factors in the consumption model. However, housing commencements and renovations alone may be insufficient to fully explain wood consumption levels during periods of economic shocks or business cycles. Macroeconomic variables such as real GDP per capita, home loan interest rates and population growth or variables accounting for dynamic patterns such as auto-regressive or moving average terms may also affect the forecasts of consumption and trade.

The forecasts for imports are likely to be affected by domestic demand in Australia and may additionally depend on macroeconomic variables for Australia’s major trading partners. The import model may also be influenced by domestic and international GDP growth and world prices.

Paper and paperboard

ABARES identified a range of potential factors affecting long-term consumption and import of paper and paperboard based on economic theory and a literature review of similar studies. Although the models described in this report provide forecasts for consumption and import of aggregate paper and paperboard, rather than individual paper grades, ABARES considered the factors affecting these components in estimating the drivers of total consumption and trade. For instance:

- advertising revenue for news companies may be an important driver of consumption and imports of newsprint
- the price of substitutes for packaging paper (such as plastic) may affect the demand for packaging and industrial paper
- consumer income may influence the volume of printing and writing paper and household and sanitary paper consumed and imported.

However, development of the econometric model involved identifying a primary demand variable and other macroeconomic variables likely to affect consumption and trade. Paper and paperboard consumption and imports were hypothesised to be a function of the value added by the manufacturing sector in Australia and other macroeconomic variables such as world prices, exchange rates and population. The manufacturing sector is a large user of packaging and industrial paper and printing and writing paper and represents a domestic demand factor.

Woodchips

Native and plantation pulplogs in Australia, which represents a primary resource for domestic production of wood products, are harvested for three major uses:

- domestic wood-based panel production
- domestic paper and paperboard production
- woodchip exports.

As a result, exports of woodchips from Australia are affected by demand for paper and paperboard and wood-based panel products and future production of these can be expected to influence the level of woodchip exports. The major export destinations are China and Japan and changes in market conditions in these countries can also affect the volume of woodchips exported from Australia. Other factors that could influence the outlook for Australia's woodchip markets include relocation of global pulp mill capacity, availability of native forest and plantation pulpwood resources in the Asia–Pacific region (particularly China), and the growing markets for renewable energy products in Europe (Townsend 2010).

Product types

The proposed wood product definitions (Table 2) represent aggregations of the actual, heterogeneous nature of product types in Australia's forestry sector. They have been aggregated to facilitate the interim, national-level analysis of demand for wood products presented in this report. Future analysis could include detailed categories at a regional level, such as separation of structural and appearance markets for sawnwood and wood-based panels. The analysis in this report provides forecasts for consumption and import of sawnwood, wood-based panels and paper and paperboard as aggregated commodity groups. Production and export forecasts have not been prepared for this report, as estimation of these parameters can only be undertaken after the datasets and forecasts developed in this report are finalised. However, forecasts for exports of woodchips have been prepared under two scenarios that outline potential domestic environments for paper and paperboard and wood-based panel production.

Table 2 Wood product definitions used in this report

Product types	Sawnwood	Cypress pine sawnwood Softwood sawnwood Hardwood sawnwood Appearance/Structural
	Wood-based panels	Plywood Medium Density Fibreboard (MDF) Particleboard
	Paper and paperboard	Newsprint Printing and writing Packaging and industrial Household and sanitary
	Woodchips	
	Other products (not studied)	Market pulp Recycled fibre Log exports Bioenergy Veneer Hardboard Softboard and other panels

Note: Hardboard, softboard and laminated veneer lumber were not studied due to a lack of production and hence apparent consumption data. Veneer was not studied as production of this panel has only been significant since 2007–08, most of which (between 70 per cent and 90 per cent) is exported and hence not consumed domestically.

3 Key datasets

The forecasting analysis presented in this report uses a number of additional assumptions relating to resource, macroeconomic and demographic parameters. The key assumptions employed in the analysis are in Table 3, and Appendix B provides a more detailed description of the sources and methodology employed to derive these parameters.

Table 3 Assumptions used in business-as-usual scenario

	Unit	2009–10 d	2019–20	2029–30	2039–40	2049–50
Domestic resources						
Hardwood plantation area	’000 ha	980	980	980	980	980
Softwood plantation area	’000 ha	1 025	1 025	1 025	1 025	1 025
Domestic markets						
Real GDP	2010A$b	1 284	1 719	2 111	2 526	2 961
Interest rate	%	6.0	6.8	6.8	6.8	6.8
Population	million	22.3	25.5	29.0	32.4	35.7
Real GDP per capita	2010A$	57 576	67 513	72 707	77 914	82 843
Manufacturing output (value added) **a**						
Base	2010A$b	107.7	127.3	131.3	131.9	129.8
High	2010A$b	–	133.7	137.8	138.5	136.3
Low	2010A$b	–	121.0	124.7	125.3	123.3
Domestic housing market						
Household size	People/ household	2.52	2.45	2.38	2.31	2.24
Share of multi-dwellings	%	32	38	41	45	48
Value of renovations **b**						
Base	2010A$b	6.5	9.1	12.6	16.8	21.7
High	2010A$b	–	9.5	13.3	17.7	22.8
Low	2010A$b	–	8.6	12.0	16.0	20.7
Dwelling commencements c						
Total dwellings						
Base	’000	165.5	184.3	193.6	198.3	214.7
High	’000	–	193.6	203.3	208.2	225.4
Low	’000	–	175.1	183.9	188.4	203.9
Detached dwellings						
Base	’000	112.1	114.8	114.0	110.0	111.8
High	’000	–	120.6	119.7	115.5	117.4
Low	’000	–	109.1	108.3	104.5	106.2
Multi-dwellings						
Base	’000	53.4	69.5	79.6	88.3	102.9
High	’000	–	73.0	83.6	92.7	108.0
Low	’000	–	66.0	75.6	83.9	97.7
World markets						
Exchange rate	US$/A$	0.88	1.00	1.00	1.00	1.00

Note: **a** A +/- 5 per cent deviation from the baseline projection for manufacturing output (value added) is used to demonstrate the sensitivity of consumption and import forecasts to variations in this variable. A 5 per cent deviation was chosen arbitrarily to acknowledge potential errors and the uncertainty associated with ABARES projection for manufacturing output. **b** Value of renovations is reported here in 2010 Australian dollars using the ABS housing CPI re-based to 2009–10 dollars to allow for comparison with other market variables. Forecasting models apply the ABS housing CPI based on 2003–04 dollars, as discussed in Appendix B. **c** The ‘high’ and ‘low’ estimates for dwelling commencements are based on a +/- 5 per cent deviation from the baseline projection for total dwellings. A 5 per cent deviation was chosen by examining the error margin for dwelling commencement projections in Love and colleagues (1999).This acknowledges the potential errors and uncertainty associated with ABARES projections for total dwelling commencements. The detailed methodology behind dwelling commencement projections used in this report is outlined in Appendix B. **d** 2009–10 is used as the base year in this table based on currently available information for all variables and to facilitate comparisons between macroeconomic variables.

Sources: Australian Government 2011; ABARES datasets

Over the period to 2049–50, real GDP growth in Australia is assumed to average 2.1 per cent a year based on projections made by the ABARES Global Trade and Environment Model (GTEM). Annual growth in manufacturing output is assumed to be slower, at 0.5 per cent based on ABARES baseline projections. Population growth is assumed to be 1.21 per cent based on assumptions made by the Australian Treasury (Australian Government 2011). The implication of these projections is that the real value of per capita GDP in Australia is estimated to reach $82 843 by 2049–50 (in 2010 dollars) compared with $57 576 in 2009–10. Given the short-run volatility of exchange rates, ABARES assumed a convergence to a long-term parity between 2011–12 and 2049–50. The detailed methodology behind these assumptions is discussed in Appendix B.

Key variables for forecasting consumption of structural timber products are those relating to housing sector activity in Australia. Based on historical trends, ABARES estimated the number of new housing commencements to 2049–50, based on assumptions made for household sizes over this period. The total number of dwelling commencements in Australia is forecast to increase from around 157 430 dwellings in 2010–11 to around 214 600 dwellings in 2049–50. This growth is driven by an increase in Australia's population and a decrease in household size.

The share of multi-dwellings in total housing activity has also been forecast over the period to 2049–50. This share is assumed to increase from 38 per cent in 2010–11 to 48 per cent by 2049–50. This is based on historical trends seen in the urbanisation of Australia's population, and described further in Appendix B. Briefly, forecasts for the proportions of multi and detached dwelling commencements, based on the *State of Australian Cities 2010* report (Infrastructure Australia 2010), suggest that much of the population growth to 2049–50 will occur in capital cities. Consequently, as large cities grow to accommodate expanding populations, it is expected that a higher proportion of multi-dwellings will be constructed. ABARES estimates that relative to 2010–11 the number of multi-dwelling commencements in Australia will increase by 31.7 per cent in 2029–30 and 70 per cent in 2049–50.

Based on historical trends in the real value of alterations and additions, the baseline estimate for growth in the real value of renovation activity averages 3.1 per cent over the forecast period, which is above the rate of housing or GDP growth (Appendix B). Hence, the real value of renovations is forecast to nearly double by 2029–30 and increase by 235 per cent in 2049–50 relative to 2010–11.

Forecasts of pulplog availability

The forecasts of pulplog availability represent ABARES estimates based on previously compiled publicly available datasets developed for *Potential effects of climate change on forests and forestry* (ABARES 2012) and *Australia's Plantation Log Supply 2010–2054* (Gavran et al. 2012) as well as anecdotal information from the industry. The detailed methodology underpinning the pulplog availability forecasts presented in this section is discussed in both reports. The forecasts are based on the assumption that harvested areas will be replanted with the same type of plantation species. The forecasts do not take into account any future management decisions such as plantations with low growth rates not being replanted and converted to another land use. As information becomes available, the forecasts may be revised to reflect further changes.

Based on log harvest ratios in Appendix B, an estimate for the actual harvest of pulplogs was derived. The results for selected periods are shown in Table 4.

Table 4 Availability of pulplogs and harvest of pulplogs in Australia (annual average in ’000 m^3), 2010–14, 2030–34 and 2045–49

Pulplog type	2010–14		2030–34		2045–49	
	Availability	Harvest	Availability	Harvest	Availability	Harvest
Total native pulplogs	4 372	4 154	3 013	2 863	3 024	2 873
Hardwood plantation pulplogs	9 162	6 225	12 820	8 710	12 172	8 270
Softwood plantation pulplogs	5 555	4 999	6 035	5 432	5 992	5 393
Total pulplogs	**19 090**	**15 379**	**21 869**	**17 005**	**21 188**	**16 536**

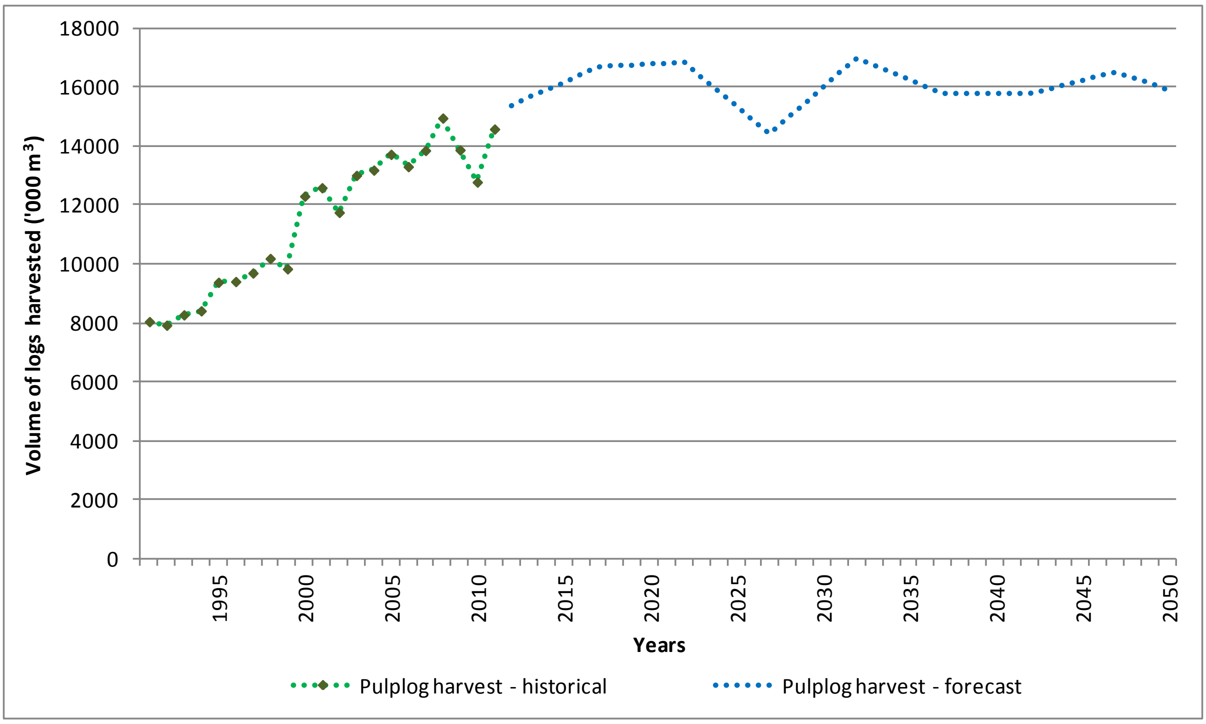
Note: There is a range of views on the potential future plantation area and production over the forecast period. Some anecdotal information from industry was incorporated in these forecasts.

Source: ABARES Datasets. Business-as-usual assumptions for pulplogs are based on the methodology outlined in ABARES (2012) and Gavran and colleagues (2012).

This report does not examine the differences in native and plantation, and hardwood and softwood pulplogs. Future research using the FORUM model could investigate the implications for production and export forecasts on the basis of supply of particular resources and inputs for different commodity groups.

The existing datasets project average annual availability of pulplogs in five-yearly periods between 2010–14 and 2045–49. In this report, ABARES assumed the average annual availability of pulplogs represents availability in the middle of each five-year period. For example, total pulplog availability in 2011–12 and 2016–17 was assumed to be 19.1 million cubic metres and 21.2 million cubic metres based on estimates for 2010–14 and 2015–19 respectively (ABARES estimates). A linear trend was then used to interpolate the availability in intervening years between each midpoint. Based on log harvest ratios in Appendix B, actual harvest of pulplogs was estimated for each year in the forecast period (Figure 1). For instance, total pulplog harvest in 2011–12 and 2016–17 was estimated to be 15.4 million cubic metres and 16.7 million cubic metres respectively.

Figure 1 Volume of logs harvested, historical 1991–11, forecasts 2012–50



Source: ABARES forecasts

4 Sawnwood forecasts

Sawnwood consumption and imports are forecast to increase between 2011–12 and 2049–50. Imports are estimated to grow marginally faster than consumption. As a result, the ratio of imports to consumption is estimated to increase over the forecast period (Table 8). However, the level of imports will also depend on other factors, particularly, domestic demand and supply. It is difficult to predict the implications for domestic production and exports given the relatively wide range presented by the 95 per cent confidence intervals over a long forecast time horizon. Further research could examine an integrated framework through the FORUM model to estimate future domestic production and exports.

Sawnwood consumption

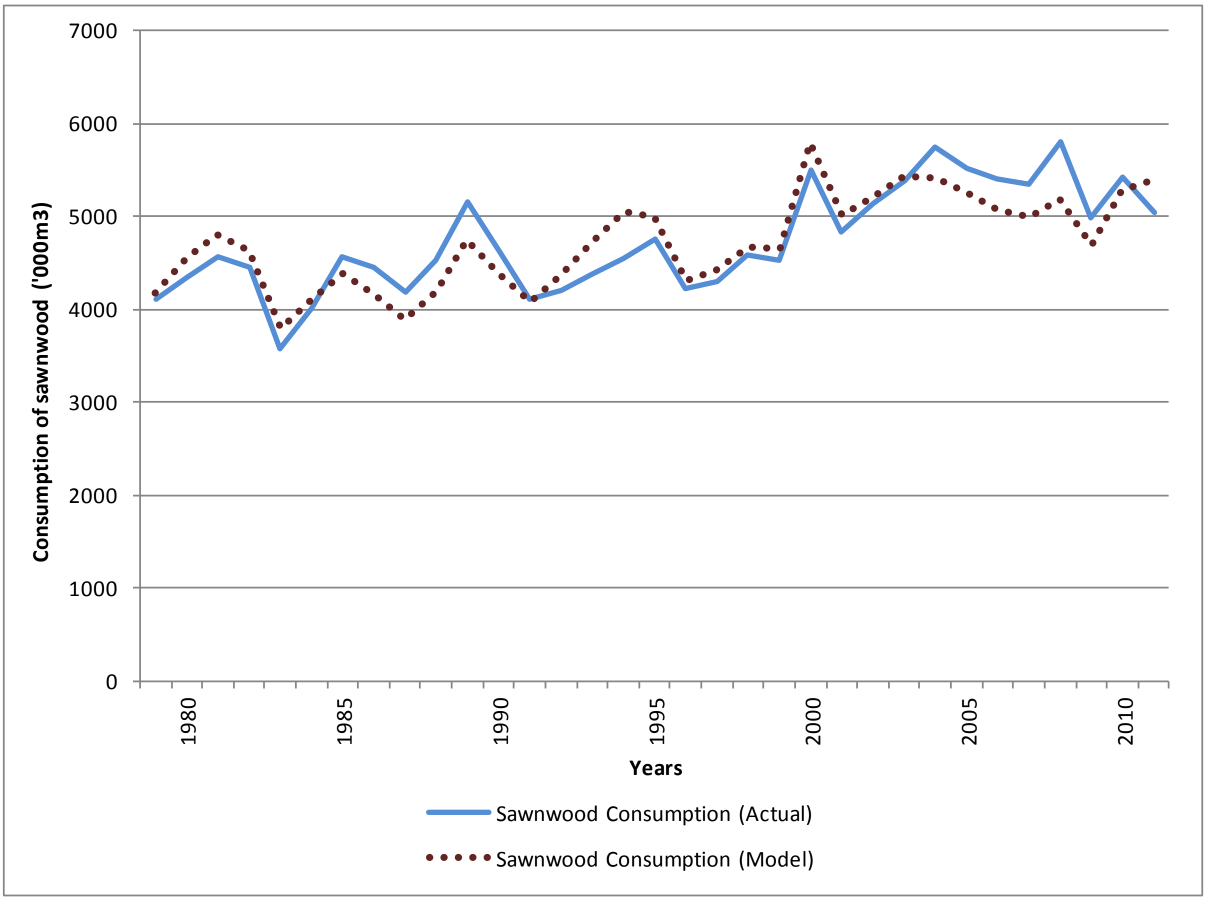
Sawnwood consumption comprises hardwood and softwood sawnwood. ABARES modelled the total quantity of sawnwood consumption for the period 2012 to 2050. Financial year historical data (1978–2011) were used to develop an econometric model to estimate and test the relationship between sawnwood consumption and commencements of multi-dwellings and detached dwellings. The housing industry is a large user of structural sawnwood and represents a domestic demand factor. The estimated model suggests that positive or negative changes in the number of dwelling commencements have a corresponding effect on sawnwood consumption. Sawnwood consumption over the past 30 years shows a marginal upward trend. Dwelling commencements are typically a leading indicator of the economy and significant shocks to the macro-economy (such as introduction of the goods and services tax in 2000 and the 2008 global financial crisis) have also affected sawnwood consumption.

A range of macroeconomic variables including real GDP per capita and household income were also considered. However, after accounting for outliers and cyclical components, the best fit for the model used commencements of detached and multi-dwellings as the primary drivers of consumption of sawnwood. Figure 2 shows how well the model fits actual data when backcasting over the period 1978–2011. Actual sawnwood consumption during this period is within the constructed 95 per cent confidence interval (which approximately represents two standard errors above and below model estimates) and is followed closely by model estimates. The model largely captures directional movements in actual data with minor departures from the trend.

Details of the model structure and assumptions are in Appendixes A and B. Forecasts in Figure 3 and Table 5 show an increase in consumption of sawnwood between 2011–12 and 2049–50. This increase is driven by the number of dwelling commencements which is forecast to increase based on assumptions described in the data section and further discussed in Appendix B. ABARES estimates that the number of total dwelling commencements will increase by 23 per cent in 2029–30 and 36 per cent in 2049–50 relative to 2010–11. This has resulted in the observed trend in sawnwood consumption forecasts (Figure 3, Table 5).

However, sawnwood consumption per capita is expected to decrease between 2029–30 and 2049–50 (Table 5). This is likely driven by concentration of population growth in large cities resulting in a structural shift from detached dwellings to multi-dwellings which are estimated to require less wood per dwelling constructed. This model is calibrated to primarily capture the structural components of sawnwood consumption and examination of the demand factors influencing appearance grade sawnwood may provide additional insights. Future research could also seek to split sawnwood consumption into hardwood and softwood components.

Figure 2 Sawnwood consumption model performance, actual 1978–2011



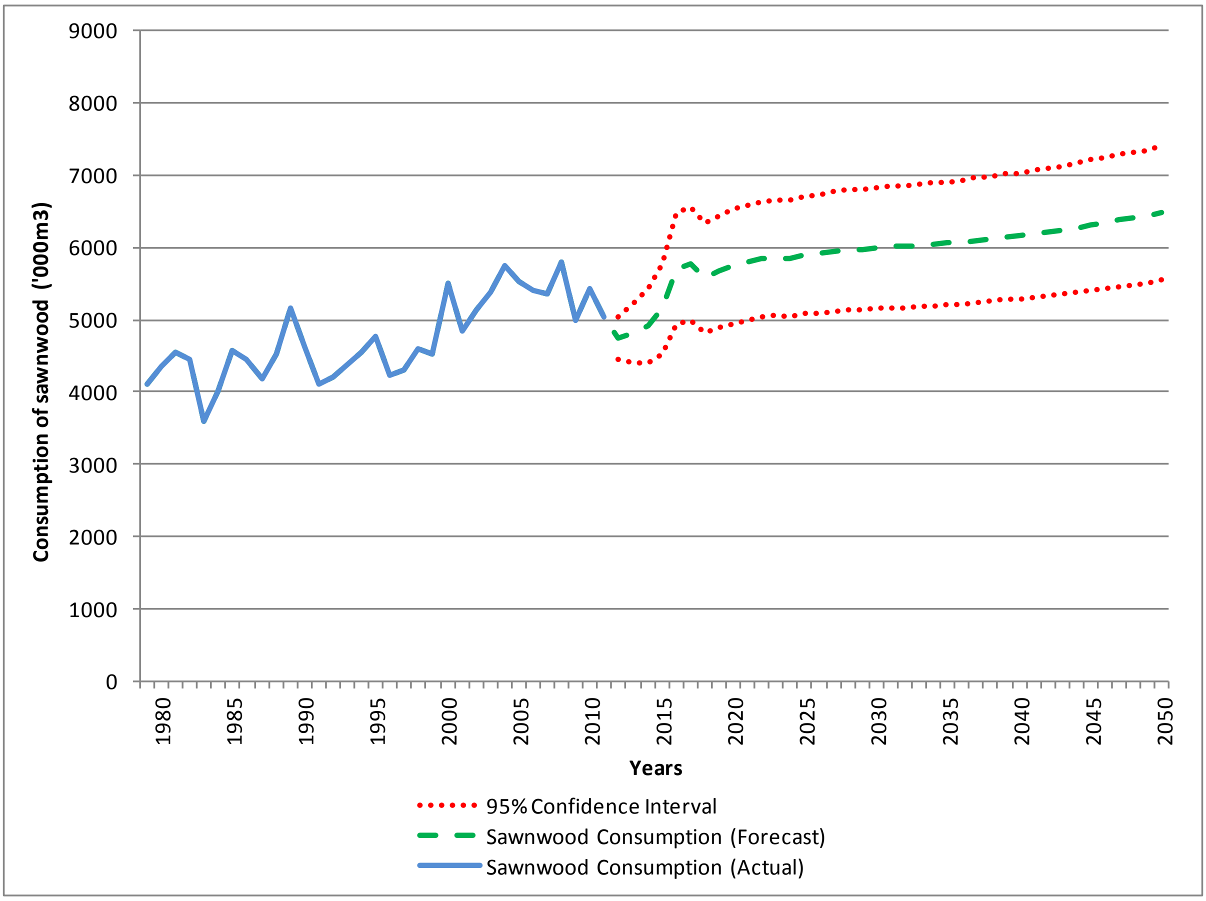
Source: ABARES models

Table 5 Summary of forecasts for modelling inputs and sawnwood consumption, 2010–14, 2030–34 and 2045–49

	Unit	2010–14	2030–34	2045–49
Mean sawnwood consumption	’000 m^3	4 991	6 014	6 374
Mean no. of detached dwelling commencements	’000	100.1	113.0	111.1
Mean no. of multi-dwelling commencements	’000	55.5	81.2	98.1
Mean sawnwood consumption per capita	m^3	0.220	0.202	0.183

Source: ABARES forecasts

Figure 3 Sawnwood consumption, actual 1978–2011, forecast 2012–50



Note: The confidence interval gives a range with 95 per cent certainty for the forecasts under business-as-usual assumptions. This range is based on the standard errors of forecasts, determined by the modelled relationship between the dependant variable and explanatory variables. Future shocks to explanatory variables and the modelled relationship are not captured by this range.
Source: ABARES forecasts

Range and sensitivity of forecasts

The forecasts Love and colleagues made in 1999 were relatively conservative and forecast consumption of sawnwood to average 4.2 million cubic metres in 2009–10 (compared with 5.4 million cubic metres actually consumed in 2009–10) and average 5.1 million cubic metres in the five years to 2039–40 (compared with a forecast 6.2 million cubic metres consumed in 2039–40 in this report). Love and colleagues used a log model to forecast structural wood products (which includes softwood and hardwood sawnwood, and panels) using detached and multi-dwelling commencements, real GDP and structural wood consumption in the previous year as explanatory variables. In this report a first difference log model was used, and accounting for outliers and cyclical components, sawnwood consumption was regressed on detached and multi-dwelling commencements.

The 95 per cent confidence interval provides a range for the forecasts under the assumptions made for the business-as-usual scenario. However, the range provided by the 95 per cent confidence interval limits the variability of exogenous parameters and does not allow for potential future errors in the assumptions. Sawnwood consumption is estimated to increase from 5.0 million cubic metres in 2010–11 to 6.0 million cubic metres in 2029–30 and 6.5 million cubic metres in 2049–50 (Table 6). The 95 per cent confidence interval suggests that consumption is likely to be between 5.1 million and 6.8 million cubic metres in 2029–30 and between 5.5 million and 7.4 million cubic metres in 2049–50.

Table 6 Forecast summary for sawnwood consumption

Year	Estimate ’000 m³	95 per cent confidence interval ’000 m³
2010–11 **a**	5 047	–
2029–30	5 984	± 831
2049–50	6 475	± 924

Note: **a** Actual as at May 2012 and may have been revised since.

Source: ABARES forecasts

The model results (outlined in Appendix A) suggest a positive coefficient for multi-dwelling and detached dwelling commencements (explanatory variables). Therefore a positive change in the explanatory variables results in a corresponding positive change in the quantity of sawnwood consumption. Specifically, a 1 per cent increase in detached or multi-dwelling commencements is estimated to result in a 0.12 per cent and 0.32 per cent increase in sawnwood consumption, respectively.

The volume of sawnwood consumption will change if the number of dwelling commencements deviates from the baseline case to the ‘high’ and ‘low’ estimates described in Table 3. Table 7 shows the sensitivity of the forecast for sawnwood consumption to changes in key demand variables—detached and multi-dwelling commencements.

Table 7 Sensitivity of sawnwood consumption forecasts

	Unit	2010–11	2029–30	2049–50
Sensitivity to changes in detached dwelling commencements a				
Detached dwelling commencements				
Base	’000	97.1	114	111.8
High	’000	–	119.7	117.4
Low	’000	–	108.3	106.2
Sawnwood consumption				
Base	’000 m³	5 047 **c**	5 984	6 475
High	’000 m³	–	6 021	6 515
Low	’000 m³	–	5 947	6 435
Sensitivity to changes in multi-dwelling commencements a				
Multi-dwelling commencements				
Base	’000	60.4	79.6	102.9
High	’000	–	83.6	108.0
Low	’000	–	75.6	97.7
Sawnwood consumption				
Base	’000 m³	5 047 **c**	5 984	6 475
High	’000 m³	–	6 079	6 578
Low	’000 m³	–	5 889	6 372

Note: The ‘high’ and ‘low’ estimates for total dwelling commencements are based on a +/- 5 per cent deviation from the baseline projection for total dwellings. A 5 per cent deviation was chosen by examining the error margin for dwelling commencement projections in Love and colleagues (1999). The detailed methodology behind ‘high’ and ‘low’ estimates for detached and multi-dwelling commencements is outlined in Appendix B. **a** Changes in sawnwood consumption are based on estimated model coefficients multiplied by the size of the percentage change in detached and multi-dwelling commencements. **b** Actual as at May 2012 and may have been revised since.

If detached dwelling commencements deviate from the baseline estimate to the ‘high’ estimate (from around 111 800 to around 117 400), sawnwood consumption increases marginally from around 6.48 million cubic metres to 6.51 million cubic metres (Table 7). That is, all other variables being equal, in 2049–50 for a 5 per cent increase in detached dwelling commencements, sawnwood consumption increases by 0.62 per cent.

The forecast for sawnwood consumption is more sensitive to changes in multi-dwelling commencements. If multi-dwelling commencements deviate from the baseline estimate to the ‘high’ estimate (from around 102 900 to around 108 000), sawnwood consumption increases from around 6.48 million cubic metres to 6.57 million cubic metres (Table 7). That is, all other variables being equal, for a 5 per cent increase in multi-dwelling commencements, sawnwood consumption increases by 1.59 per cent.

Sawnwood imports

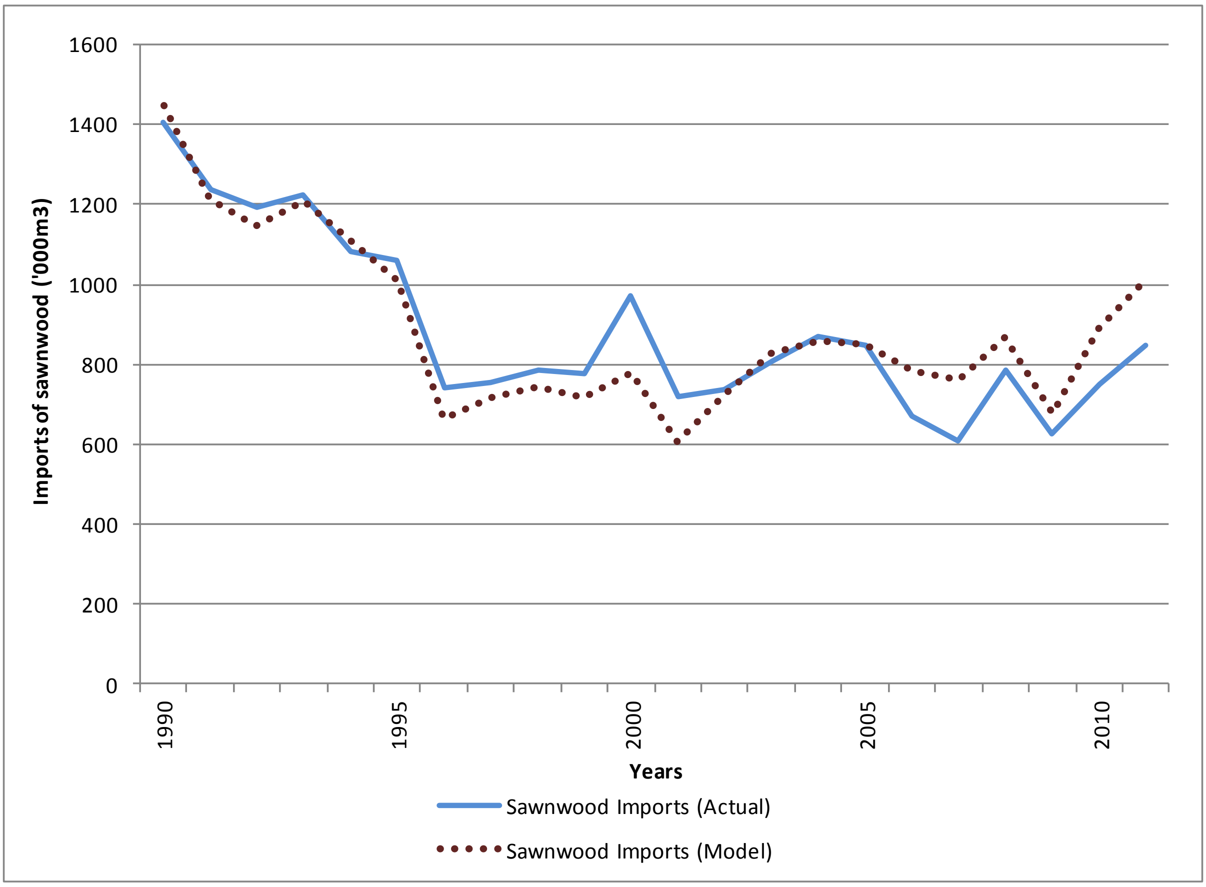
Sawnwood imports to Australia comprise hardwood and softwood sawnwood. ABARES modelled the total quantity of sawnwood imports for the period 2011–12 to 2049–50. Financial year historical data (1988–89 to 2010–11) were used to develop an econometric model to estimate and test the relationship between sawnwood imports and the number of multi-dwellings commenced together with the Australian to US dollar exchange rate. Multi-dwelling commencements act as a domestic demand indicator affecting the level of sawnwood imports particularly for structural wood and furniture.

The Australian to US dollar exchange rate is a measure of the purchasing power of the Australian dollar. An appreciation in the Australian dollar generally results in cheaper imports. As a result, it is estimated that positive or negative changes in both explanatory variables will have a corresponding positive or negative effect on sawnwood imports. Figure 4 shows the accuracy of the constructed model when backcasting over the period 1989–2011. Actual sawnwood import during this period is within the constructed 95 per cent confidence interval (which approximately represents two standard errors above and below model estimates) and is followed closely by model estimates. The model appears to capture almost all directional movements in actual data and although the approximations are sometimes exaggerated, actual data remains within the 95 per cent confidence interval.

The volume of imports will also depend on domestic demand and supply conditions. Although the model includes a demand indicator (multi-dwelling commencements), domestic consumption was not included as an explanatory variable given the definition of apparent consumption. Future research could examine domestic production and exports through the ABARES FORUM model and could seek to integrate consumption and import forecasts to present a complete outlook. Globally, changes in the US housing market and growth in Chinese demand for softwood sawnwood may influence sawnwood trade. The United States is the world’s largest importer of softwood sawnwood and China looks to be increasing its share in global sawnwood markets (Burke & Townsend 2011).

Details of the model structure and assumptions are presented in Appendix A and Appendix B. Despite a fall in the volume of imports over the decade between 1990 and 2000, imports of sawnwood increased and are forecast to continue increasing between 2011–12 and 2049–50 (Figure 5, Table 8). The increase in sawnwood imports is driven by an increase in multi-dwelling commencements (see *Key datasets,* Appendix B). Exchange rates are estimated to have a relatively smaller influence on forecasts for sawnwood imports.

Figure 4 Sawnwood imports model performance, actual 1990–2011



Source: ABARES models

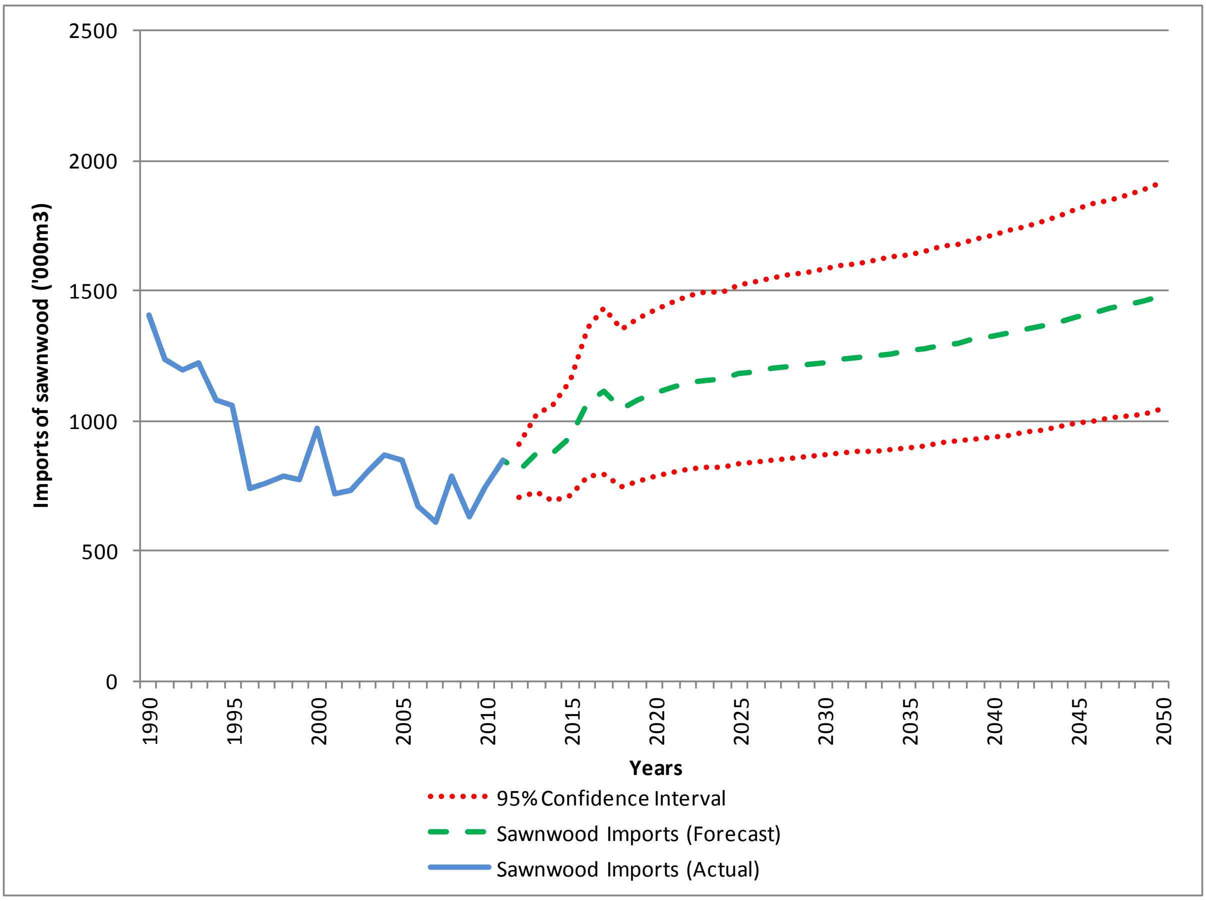
The observed trend in sawnwood import forecasts is driven by the increased growth in multi-dwelling commencements. The forecast mean sawnwood imports per capita is also estimated to increase marginally before levelling off (Table 8). This corresponds with a faster growth in imports than in population initially as suggested by strong growth in demand indicators such as the number of multi-dwelling commencements. Between 2029–30 and 2049–50 this growth is expected to stabilise matching the growth in population. The model for sawnwood imports places a higher weight than the model for sawnwood consumption on the number of multi-dwelling commencements. The number of multi-dwelling commencements is a primary explanatory variable in both models and is projected to account for most of the increase in total dwelling commencements. Thus, the forecast mean proportion of sawnwood imports to consumption is estimated to increase.

Table 8 Summary of forecasts for modelling inputs and sawnwood imports (annual average), 2010–14, 2030–34 and 2045–49

	Unit	2010–14	2030–34	2045–49
Mean sawnwood imports	’000 m^3	830	1 242	1 430
Mean no. of multi-dwelling commencements	’000	55.5	81.2	98.1
Mean value of the US dollar against the Australian dollar	US$/A$	0.995	1.000	1.000
Mean sawnwood imports per capita	m^3	0.037	0.042	0.041
Mean proportion of sawnwood imports to consumption	%	16.6	20.7	22.4

Source: ABARES forecasts

Figure 5 Sawnwood imports, actual 1990–2011, forecast 2012–50



Note: The confidence interval gives a range with 95 per cent certainty for the forecasts under the business-as-usual assumptions. This range is based on the standard errors of forecasts, determined by the modelled relationship between the dependant variable and explanatory variables. Future shocks to explanatory variables and the modelled relationship are not captured by this range.
Source: ABARES forecasts

Range of forecasts

Sawnwood imports are forecast to increase by around 75 per cent over the 40-year forecast period (Table 9), from around 0.8 million cubic metres in 2010–11 to 1.2 million cubic metres in 2029–30 and 1.5 million cubic metres in 2049–50. The 95 per cent confidence interval provides a range for the forecasts under the assumptions made for the business-as-usual scenario. Here sawnwood imports are likely to be between 0.9 million and 1.6 million cubic metres in 2029–30 and between 1 million and 1.9 million cubic metres in 2049–50.

Table 9 Forecast summary for sawnwood imports

Year	Estimate ’000 m³	95 per cent confidence interval ’000 m³
2010–11 **a**	846	–
2029–30	1 225	± 357
2049–50	1 481	± 438

Note: **a** Actual as at May 2012 and may have been revised since.
Source: ABARES forecasts

5 Wood-based panel forecasts

Wood-based panel consumption and imports are forecast to increase between 2011–12 and 2049–50. Consumption is forecast to grow at a faster rate than imports. Therefore, the ratio of imports to consumption is forecast to decrease over the analysis period (Table 13). Consumption of wood-based panels is closely linked to the number of multi-dwelling commencements. As well, imports may be affected by domestic supply factors. It is worth noting that imports of wood-based panels have historically been relatively small compared with other wood product imports.

Wood-based panel consumption

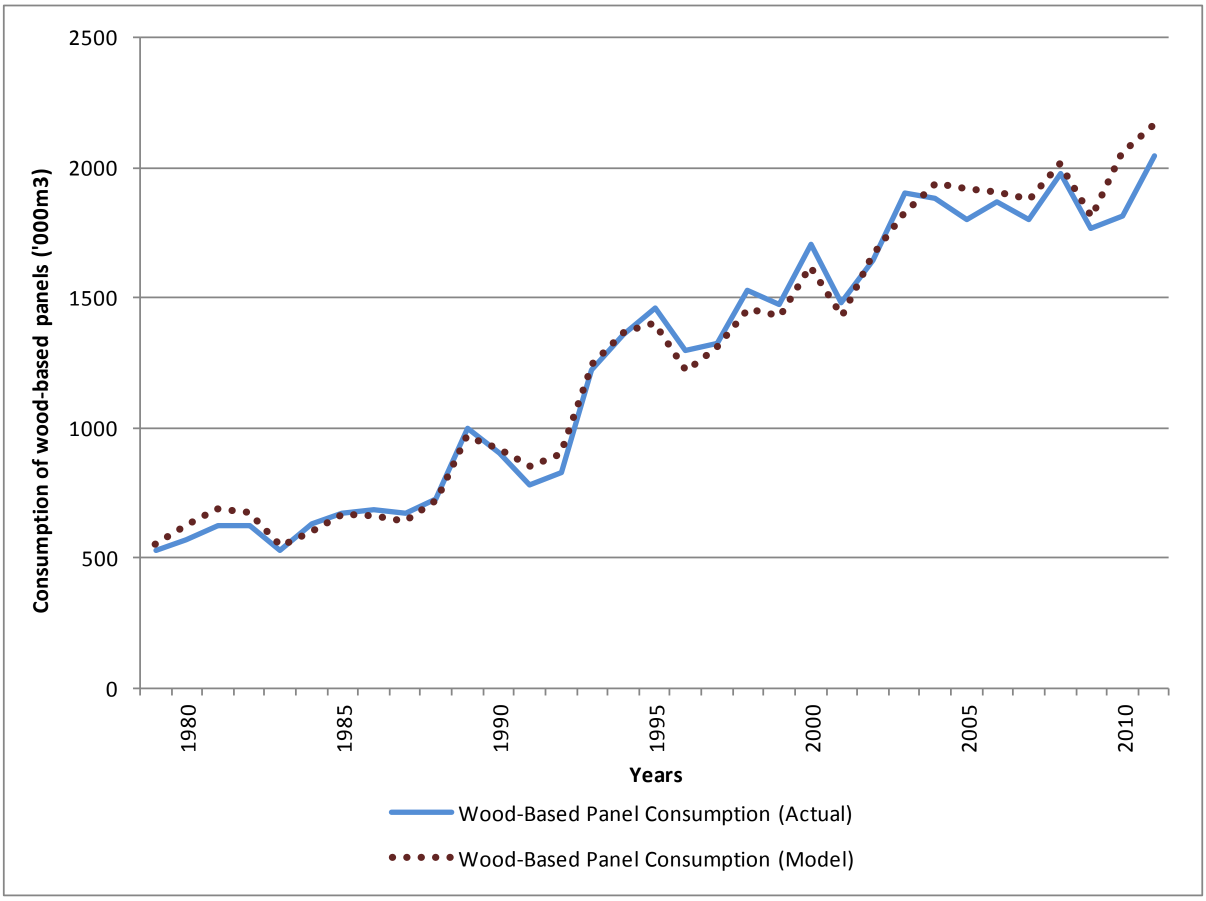
Wood-based panel consumption estimated in this report consists of plywood, particleboard and medium density fibreboard. These panels are largely used for structural purposes in building activities. Given the wide variety of uses for wood-based panels, the models were calibrated to focus on structural timber uses. Hardboard, softboard and laminated veneer lumber were not studied due to a lack of sufficient production and hence apparent consumption data. Veneer was not included as production of this panel has only been significant since 2007–08, most of which (between 70 and 90 per cent) is exported and hence not consumed domestically.

ABARES modelled forecasts for the total quantity of wood-based panel consumption for the period 2012 to 2049–50. Financial year historical data (1978–2011) were used to develop an econometric model to estimate and test the relationship between wood-based panel consumption and multi-dwelling commencements together with the real value of approved alterations and additions (or renovations) to existing houses. The housing industry is a large user of wood-based panels—primarily in wall, roof and floor sheathing—but also in cabinets, mouldings and doors. Wood-based panels are also used in furniture construction.

Analysing wood-based panel consumption shows the need to account for outliers and a cyclical trend in the data. A number of macroeconomic variables including real GDP per capita and household income were also considered. Figure 6 shows how well the model fits actual data when backcasting over the period 1978–2011. Actual wood-based panel consumption during this period is within the constructed 95 per cent confidence interval (which approximately represents two standard errors above and below model estimates) and is followed closely by model estimates. In particular, the model accurately captures directional movements in actual data in the 1980s and 1990s with minor departures from the trend in the 2000s.

Details of the model structure and assumptions are presented in Appendix A and Appendix B. The forecasts in Figure 7 and Table 11 show an increase in consumption of wood-based panels between 2011–12 and 2049–50. This increase is driven by the number of multi-dwelling commencements and the real value of renovations, which are forecast to increase, based on assumptions in Appendix B. ABARES estimates the number of multi-dwelling commencements to rise by 32 per cent in 2029–30 and 70 per cent in 2049–50 relative to 2010–11. Similarly, the real value of renovations is estimated to increase 95 per cent by 2029–30 and 235 per cent by 2049–50 relative to 2010–11. This has resulted in the observed trend in wood-based panel consumption forecasts (Figure 7, Table 11).

Figure 6 Wood-based panel consumption model performance, actual 1978–2011



Source: ABARES models

Infrastructure Australia (2010) estimates that much of Australia's population growth to 2049–50 will occur in capital cities, leading to a higher proportion of multi-dwelling commencements compared with detached dwellings. The value of approved alterations and additions to existing dwellings, as a proportion of the value of approved new dwellings, has increased over time and ABARES estimates this trend will continue to 2049–50.

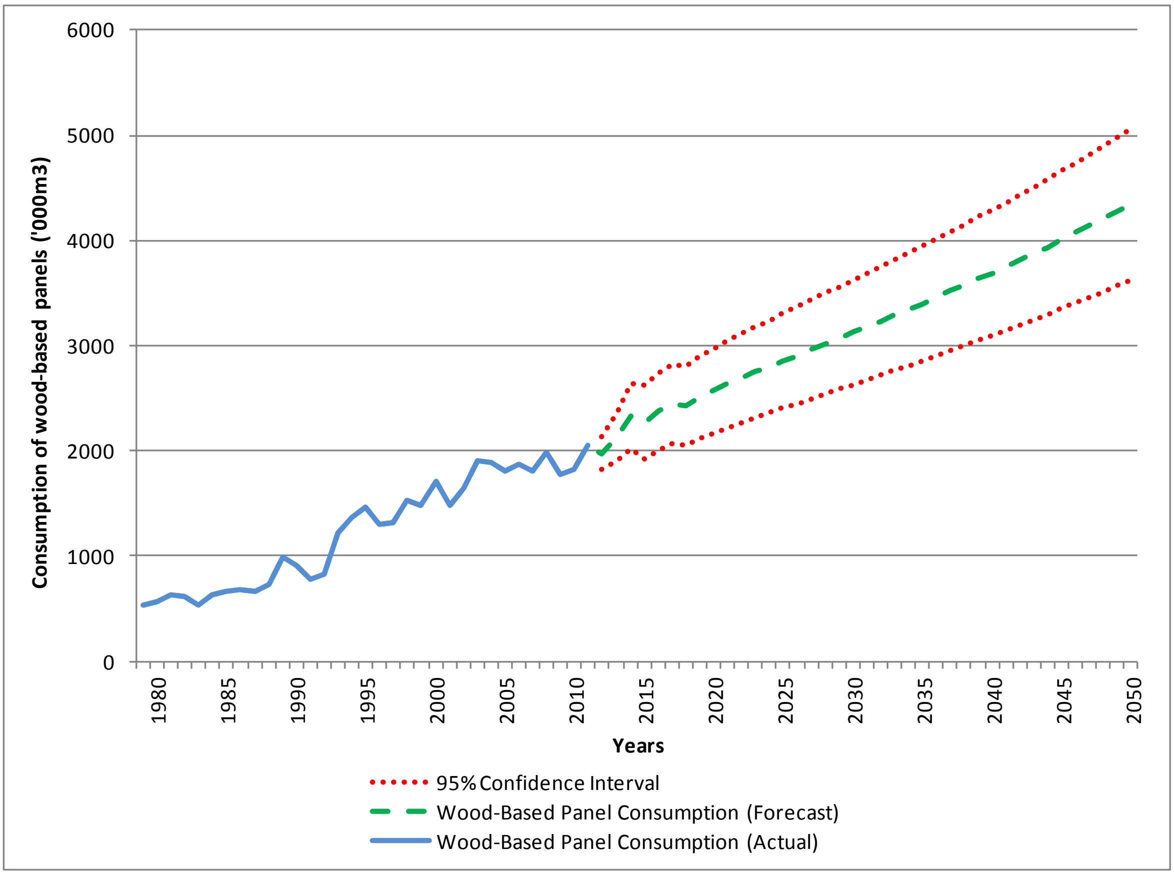
The forecast mean wood-based panel consumption per capita is also estimated to increase (Table 10). This may be due to smaller household sizes leading to higher multi-dwelling commencements per capita. The forecast increase in value of renovations may also influence the volume of wood-based panel consumption per capita. However, as with sawnwood models, this model is calibrated to primarily capture the structural uses of wood-based panels. Future research could seek to investigate different uses for different types of panels.

Table 10 Summary of forecasts for modelling inputs and wood-based panel consumption (annual average), 2010–14, 2030–34 and 2045–49

	Unit	2010–14	2030–34	2045–49
Mean wood-based panel consumption	'000 m^3	2 060	3 235	4 137
Mean value of multi-dwelling commencements	'000	55.5	81.2	98.1
Mean value of approved alterations and additions	2010A$b	6.83	13.44	20.20
Mean wood-based panel consumption per capita	m^3	0.092	0.112	0.121

Source: ABARES forecasts

Figure 7 Wood-based panel consumption, actual 1978–2011, forecast 2012–50



Note: The confidence interval gives a range with 95 per cent certainty for the forecasts under the business-as-usual assumptions. This range is based on the standard errors of forecasts, determined by the modelled relationship between the dependant variable and explanatory variables. Future shocks to explanatory variables and the modelled relationship are not captured by this range.

Source: ABARES forecasts

Range of forecasts

Love and colleagues (1999) used a log model to forecast consumption of total structural wood products. Consumption of wood-based panels was forecast to average 1.5 million cubic metres in the five years to 2009–10 (compared with 1.8 million cubic metres actually consumed in 2009–10) and average 1.8 million cubic metres in the five years to 2039–40 (compared with a forecast 3.7 million cubic metres consumed in 2039–40 in this report). Addressing one of the challenges Love and colleagues faced in 1999, consumption and trade of sawnwood and wood-based panels were forecast separately in this report. Analysis shows that consumption of sawnwood and of wood-based panels do not necessarily have similar trends over time.

The 95 per cent confidence interval provides a range for the forecasts under the assumptions made for the business-as-usual scenario. However, the range provided by the 95 per cent confidence interval limits the variability of exogenous parameters and does not allow for potential future errors in the assumptions. ABARES forecasts that consumption of wood-based panels will increase from 2.0 million cubic metres in 2010–11 to 3.1 million cubic metres in 2029–30 and 4.3 million cubic metres in 2049–50 (Table 11). The 95 per cent confidence interval provides a range for these forecasts and suggests wood-based panel consumption will be between 2.6 million and 3.6 million cubic metres in 2029–30 and between 3.6 million and 5.1 million cubic metres in 2049–50.

Table 11 Forecast summary for wood-based panel consumption

Year	Estimate '000 m³	95 per cent confidence interval '000 m³
2010–11	2 048 **a**	–
2029–30	3 126	± 497
2049–50	4 341	± 715

Note: **a** Actual as at May 2012 and may have been revised since.

Source: ABARES forecasts

The model results (outlined in Appendix A) suggest a positive coefficient for both multi-dwelling commencements and the value of renovations (explanatory variables). Therefore a positive change in the explanatory variables results in a corresponding positive change in the quantity of wood-based panel consumption. Specifically, a 1 per cent increase in multi-dwelling commencements results in a 0.26 per cent increase in the rate of growth in wood-based panel consumption. Similarly, a 1 per cent increase in the value of renovations results in a 0.48 per cent increase in wood-based panel consumption.

ABARES tested the sensitivity of the forecast for wood-based panel consumption for a deviation in the number of multi-dwelling commencements from the baseline case to the 'high' and 'low' estimates and changes in the value of renovations (Table 12).

Table 12 Sensitivity of wood-based panel consumption forecasts

	Unit	2010–11	2029–30	2049–50
Sensitivity to changes in value of renovations a				
Value of renovations				
Base	2010A$b	6.7	12.6	21.7
High	2010A$b	–	13.3	22.8
Low	2010A$b	–	12.0	20.7
Wood-based panel consumption				
Base	'000 m³	2 048 **b**	3 126	4 341
High	'000 m³	–	3 201	4 445
Low	'000 m³	–	3 051	4 236
Sensitivity to changes in multi-dwelling commencements a				
Multi-dwelling commencements				
Base	'000	60.4	79.6	102.9
High	'000	–	83.6	108.0
Low	'000	–	75.6	97.7
Wood-based panel consumption				
Base	'000 m³	2 048 **b**	3 126	4 341
High	'000 m³	–	3 167	4 398
Low	'000 m³	–	3 085	4 283

Note: The 'high' and 'low' estimates for total dwelling commencements are based on a +/- 5 per cent deviation from the baseline projection for total dwellings. A 5 per cent deviation was chosen by examining the error margin for dwelling commencement projections in Love and colleagues (1999). The detailed methodology behind 'high' and 'low' estimates for detached and multi-dwelling commencements is outlined in Appendix B. **a** Changes in wood-based panel consumption are based on estimated model coefficients multiplied by the size of the percentage change in value of renovations and multi-dwelling commencements. **b** Actual as at May 2012 and may have been revised since.

The forecast for wood-based panel consumption is more sensitive to changes in the value of renovations. If value of renovations deviate from the baseline estimate and increases by 5 per cent in 2049–50 (from around $21.7 billion to around $22.8 billion), wood-based panel consumption increases from around 4.34 million cubic metres to 4.44 million cubic metres (Table 12). That is, all other variables being equal, in 2049–50 for a 5 per cent increase in value of renovations, wood-based panel consumption increases by 2.41 per cent.

If multi-dwelling commencements deviate from the baseline estimate to the 'high' estimate (from around 102 900 to around 108 000), wood-based panel consumption increases from around 4.34 million cubic metres to 4.40 million cubic metres (Table 12). That is, all other variables being equal, for a 5 per cent increase in multi-dwelling commencements, wood-based panel consumption increases by 1.32 per cent.

Wood-based panel imports

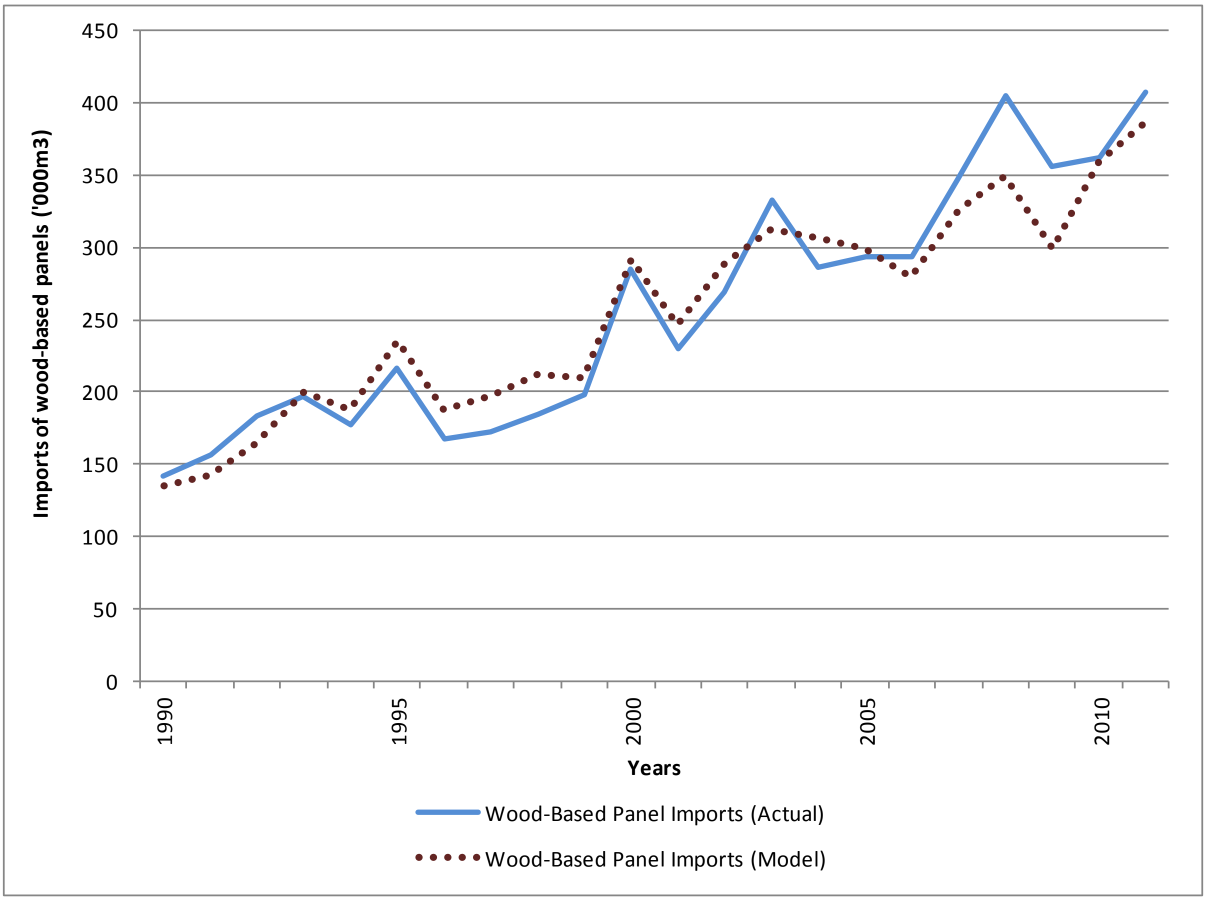
Wood-based panel imports consist of plywood, particleboard and medium density fibreboard. ABARES modelled forecasts for the total quantity of wood-based panel imports for the period 2012 to 2050. Financial year historical data (1989–2011) were used to develop an econometric model to estimate and test the relationship between wood-based panel imports and multi-dwellings commenced. Figure 8 shows how well the model fits actual data when backcasting over the period 1989–2011. Actual wood-based panel imports during this period are within the constructed 95 per cent confidence interval (which approximately represents two standard errors above and below model estimates) and is followed closely by model estimates. The model largely imitates the trend in actual data although there is evidence of increased variation in later years which is expected given the size of the sample and small volumes of wood-based panel imports. Rigorous testing shows that the model is stable and provides accurate forecasts under the assumptions made for the business-as-usual scenario.

Compared with other wood product imports, the volume of wood-based panels imported has been relatively small historically. However, domestic economic conditions and factors affecting the domestic supply and demand for panels will affect the volume of imports. Some international effects may also be captured through the Australian to US dollar exchange rate. Future research could investigate major international markets for panels and their influence on Australian trade.

Details of the model structure and assumptions are presented in Appendix A and Appendix B. The forecasts (Figure 9, Table 13) show an increase in imports of wood-based panels between 2011–12 and 2049–50 driven by an increase in multi-dwelling commencements. The model suggests that positive or negative changes in multi-dwelling commencements will have a corresponding positive or negative effect on wood-based panel imports. The number of multi-dwelling commencements is forecast to increase based on assumptions presented in Appendix B. This has led to the observed trend in wood-based panel import forecasts (Figure 9, Table 13).

The forecast mean quantity of wood-based panel imports per capita between 2011–12 and 2049–50, is estimated to remain stable (Table 13). This reflects a growth in wood-based panel imports that roughly matches growth in population over the forecast period. The forecast mean proportion of wood-based panel imports to consumption is estimated to decrease, reflecting higher growth in consumption compared with growth in imports under the business-as-usual assumptions.

Figure 8 Wood-based panel imports model performance, actual 1989–2011



Source: ABARES models

Table 13 Summary of forecasts for modelling inputs and wood-based panel imports (annual average), 2010–14, 2030–34 and 2045–49

	Unit	2010–14	2030–34	2045–49
Mean wood-based panel imports	’000 m^3	370	466	524
Mean multi-dwellings commencements	’000	55.5	81.2	98.1
Mean panel imports per capita	m^3	0.016	0.016	0.015
Mean proportion of panel imports to consumption	%	18.0	14.4	12.7

Source: ABARES forecasts

Figure 9 Wood-based panel imports, actual 1989–2011, forecast 2012–50

Note: The confidence interval gives a range with 95 per cent certainty for the forecasts under the business-as-usual assumptions. This range is based on the standard errors of forecasts, determined by the modelled relationship between the dependant variable and explanatory variables. Future shocks to explanatory variables and the modelled relationship are not captured by this range.

Source: ABARES forecasts

Range of forecasts

ABARES forecasts a modest increase in wood-based panel imports over the period to 2049–50 (Table 14). Imports are estimated to increase from around 407 000 cubic metres in 2010–11 to 460 000 cubic metres in 2029–30 and 539 000 cubic metres in 2049–50. The 95 per cent confidence interval provides a range for the forecasts under the assumptions made for the business-as-usual scenario and suggests that imports will be between 300 000 cubic metres and 621 000 cubic metres in 2029–30 and between 345 000 cubic metres and 733 000 cubic metres in 2049–50.

Table 14 Forecast summary for wood-based panel imports

Year	Estimate ’000 m^3	95 per cent confidence interval ’000 m^3
2010–11	407 **a**	–
2029–30	460	± 161
2049–50	539	± 194

Note: **a** Actual as at May 2012 and may have been revised since.

Source: ABARES forecasts

6 Paper and paperboard forecasts

Consumption and imports of paper and paperboard are forecast to increase between 2011–12 and 2049–50. As consumption is forecast to grow at a slower rate than imports, the ratio of imports to consumption is expected to increase (Table 18). This is largely due to assumptions made to forecast value added by the manufacturing sector. ABARES estimates that the contribution of manufacturing to real GDP decreases over the forecast period. In this report, value added by manufacturing sector and real GDP per capita are the primary explanatory variables for forecasting consumption and imports of paper and paperboard products. Imports may additionally be affected by domestic processing capacity and supply, and international market conditions as indicated by world prices.

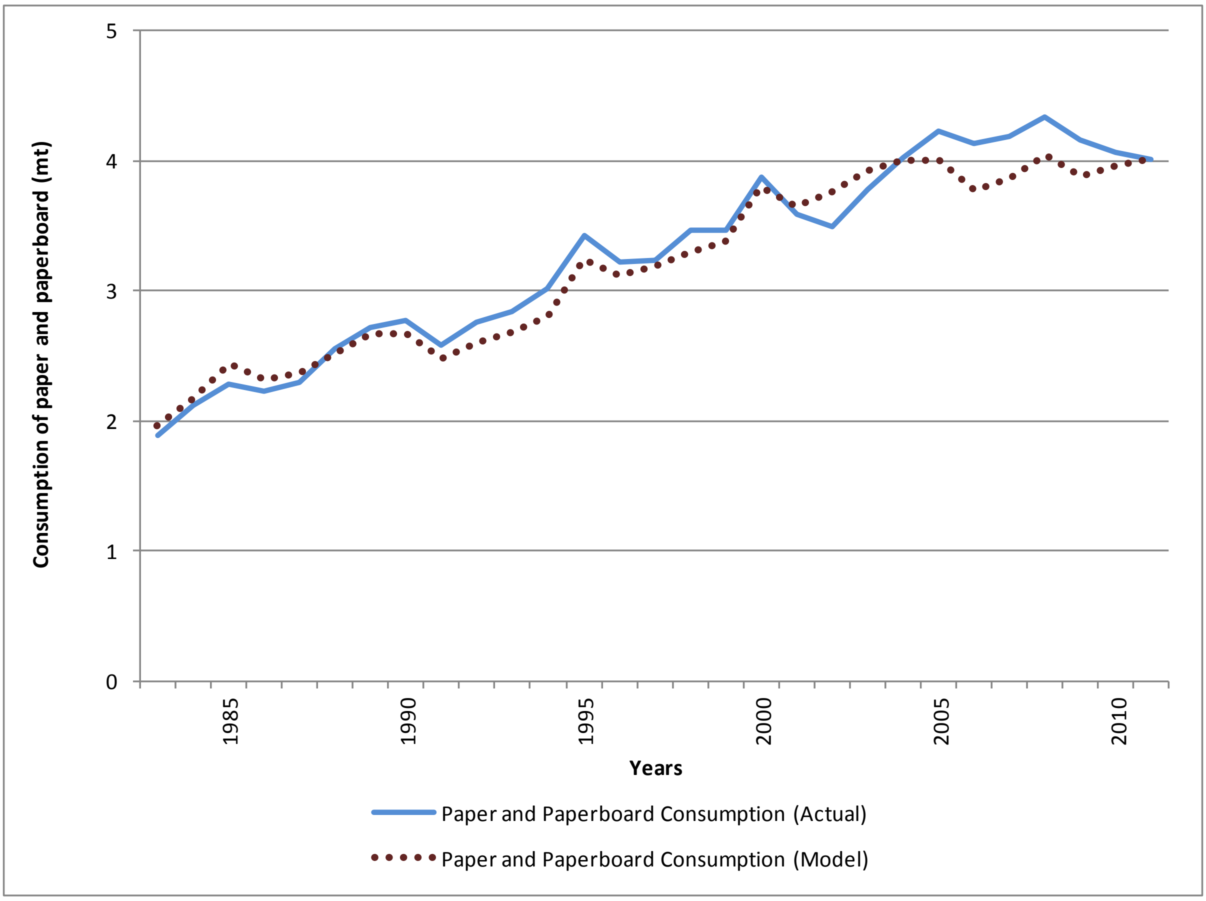
Paper and paperboard consumption

Paper and paperboard consumption comprises consumption of newsprint, household and sanitary paper, packaging and industrial paper and printing and writing paper. ABARES modelled forecasts for the total quantity of paper and paperboard consumption for the period 2012 to 2050. Financial year historical data (1983–2011) were used to develop an econometric model to estimate and test the relationship between paper and paperboard consumption and value added by manufacturing (chain volume measure). The manufacturing sector is a large user of packaging and industrial paper and printing and writing paper and represents a domestic demand factor. Consumption of these two grades of paper comprised 78 per cent of total paper and paperboard consumption in Australia. It is estimated that positive or negative changes in the value of manufacturing output have a corresponding effect on aggregate paper and paperboard consumption.

It is difficult to estimate aggregate consumption because paper and paperboard products have a wide range of end users (Edquist & Morris 1986). For example, while changes in the manufacturing sector are unlikely to influence consumption or trade of newsprint and household and sanitary paper products, they could be affected by changes in consumer income. Ideally, models for forecasting paper consumption would consider the different grades of paper separately and this may be examined in future research and analysis. Nevertheless, given that packaging and industrial, and printing and writing paper, account for a significant proportion of apparent consumption (78 per cent in 2010–11), the model presented in this report uses the value added by the manufacturing sector as the primary explanatory variable. Figure 10 shows how well the model fits actual data when backcasting over the period 1983–2011.

Actual paper and paperboard consumption during this period is within the constructed 95 per cent confidence interval (which approximately represents two standard errors above and below model estimates) and is followed closely by model estimates. The model largely captures directional movements in actual data with minor departures from the trend. Rigorous testing shows the model to be stable and accurate when forecasting under assumptions made for the business-as-usual scenario.

Figure 10 Paper and paperboard consumption model performance, actual 1983–2011



Source: ABARES models

Given that value added by manufacturing output is forecast to increase out to 2029–30 before levelling off and declining marginally thereafter (Appendix B), paper and paperboard consumption is forecast to increase between 2011–12 and 2049–50 (Figure 11, Table 16). This is primarily due to the model structure (Appendix A) that shows a significant relationship for manufacturing value added but also includes a constant term to capture the historical time trend in aggregate paper consumption. This constant is necessary as it captures some of the variation in newsprint and household grades of paper, thereby allowing use of manufacturing output to explain consumption of packaging and printing grades of paper. The historical time trend captured by this constant contributes to the trend in the forecast for aggregate paper and paperboard consumption and is moderated by the primary explanatory variable—value added by manufacturing output. Thus in later years, the decrease in manufacturing reduces paper and paperboard consumption below the historical time trend. As real GDP is forecast to have stable growth over this period, ABARES implicitly assumes that the value added by the manufacturing sector to real GDP decreases. Details of the model structure and assumptions are presented in Appendix A and Appendix B, respectively.

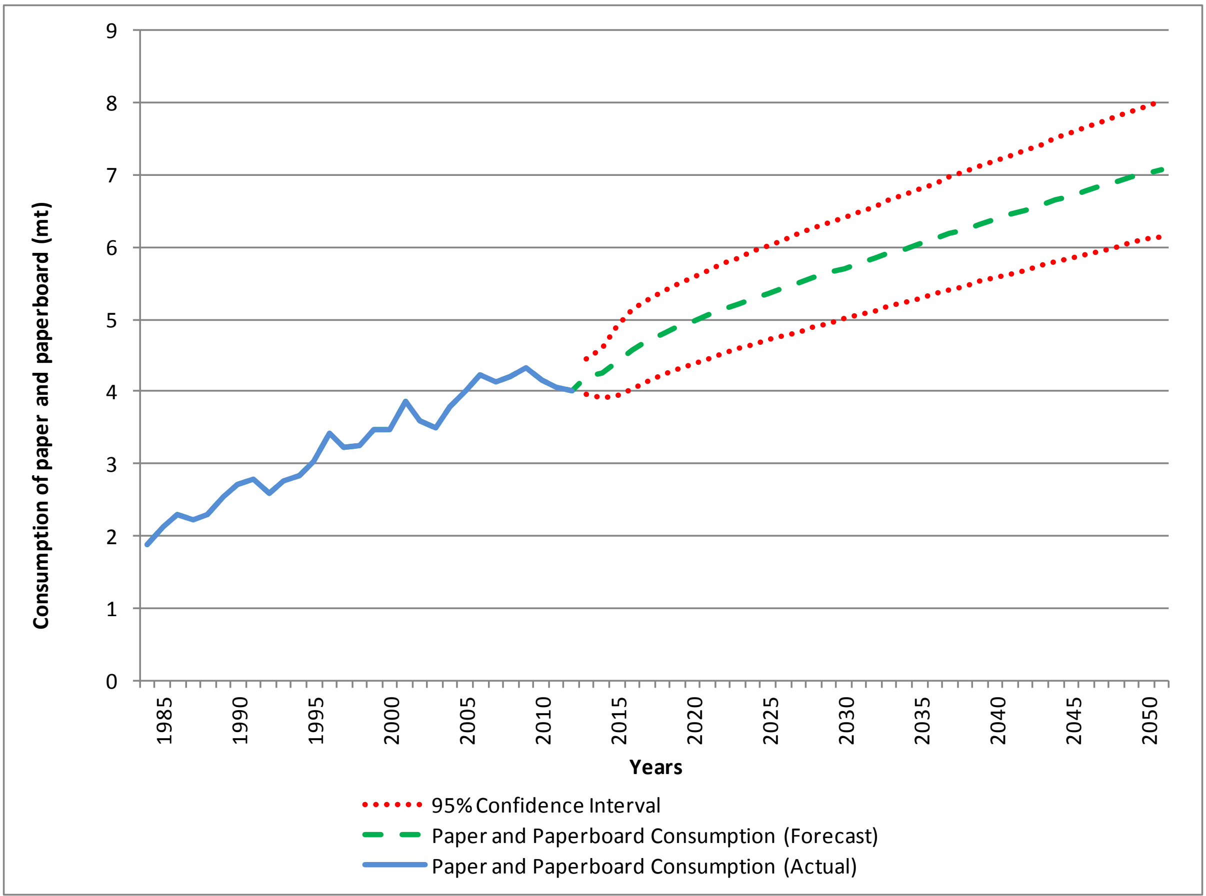
The mean quantity of paper and paperboard consumption is forecast to increase (Table 15) driven by the increase in value added by the manufacturing sector. There is a marginal rise forecast in consumption per capita. Between 2010–14 and 2030–34 consumption per capita is expected to increase but will level off between 2030–34 and 2045–49 as manufacturing value added also levels off. As the manufacturing sector is the major driver here, this forecast implies that growth in consumption of packaging and industrial paper and printing and writing paper will account for most of the increase in total consumption of paper and paperboard. A higher growth in consumption than in population between 2010–14 and 2030–34 assumes a future increased use of these paper products. Future research could investigate different uses for different types of paper and provide insights for additional drivers.

Table 15 Summary of forecasts for modelling inputs and paper and paperboard consumption (annual average), 2010–14, 2030–34 and 2045–49

	Unit	2010–14	2030–34	2045–49
Mean paper and paperboard consumption	kt	4 186	5 911	6 903
Mean value added by manufacturing	2010 A$/$b	113.7	131.6	130.8
Mean paper and paperboard consumption per capita	tonnes	0.184	0.199	0.199

Source: ABARES forecasts, Australian Government 2011

Figure 11 Paper and paperboard consumption, actual 1983–2011, forecast 2012–50



Note: The confidence interval gives a range with 95 per cent certainty for the forecasts under the business-as-usual assumptions. This range is based on the standard errors of forecasts, determined by the modelled relationship between the dependant variable and explanatory variables. Future shocks to explanatory variables and the modelled relationship are not captured by this range.
Source: ABARES forecasts

Range of forecasts

The model Love and colleagues used in 1999 to forecast paper and paperboard consumption was based on life-cycle theory which postulates that consumption of a product follows a bell-shaped trend over its full life span and an S-shaped curve over its growth period. The model forecast total paper and paperboard consumption to average 4.3 million cubic metres in the five years to 2009–10 (compared with the 4 million cubic metres actually consumed in 2009–10) and average 6 million cubic metres in the five years to 2039–40 (compared with a forecast 5.9 million cubic metres consumed in 2040 in this report). The life-cycle method is not without challenges, particularly the need to assume a discrete stage in the life cycle for each product. Hence the approach used in this report is to account for business cycle components and estimate the relationship between likely demand indicators and consumption.

The 95 per cent confidence interval provides a range for the forecasts under the assumptions made for the business-as-usual scenario. However, the range provided by the 95 per cent confidence interval limits the variability of exogenous parameters and does not allow for potential future errors in the assumptions. Forecasts show that paper and paperboard consumption will increase from 4 million tonnes in 2010–11 to 5.8 million tonnes in 2029–30 and 7.1 million tonnes in 2049–50 (Table 16). The 95 per cent confidence interval provides a range for these forecasts and suggests that paper and paperboard consumption will be between 5.1 million tonnes and 6.5 million tonnes in 2029–30 and between 6.2 million tonnes and 8 million tonnes in 2049–50.

Table 16 Forecast summary for paper and paperboard consumption

Year	Estimate ’000 tonnes	95 per cent confidence interval ’000 tonnes
2010–11	4 012 **a**	–
2029–30	5 774	± 715
2049–50	7 083	± 932

Note: **a** Actual as at May 2012 and may have been revised since.

Source: ABARES forecasts

The model results (outlined in Appendix A) suggest a positive coefficient for value added by manufacturing output (explanatory variable). Therefore a positive change in the explanatory variable results in a corresponding positive change in the quantity of wood-based panel consumption. Specifically, a 1 per cent increase in manufacturing output results in a 0.82 per cent increase in paper and paperboard consumption. ABARES tested the sensitivity of the forecast for paper and paperboard consumption for changes in manufacturing (Table 12).

Table 17 Sensitivity of paper and paperboard consumption forecasts

	Unit	2010–11	2029–30	2049–50
Sensitivity to changes in value added by the manufacturing output a				
Manufacturing output (value added)				
Base	2010A$b	107.8	131.3	129.8
High	2010A$b	–	137.8	136.3
Low	2010A$b	–	124.7	123.3
Paper and paperboard consumption				
Base	’000 tonnes	4 012 b	5 774	7 083
High	’000 tonnes	–	6 011	7 374
Low	’000 tonnes	–	5 537	6 793

Note: A +/- 5 per cent deviation from the baseline projection for manufacturing output (value added) is used to demonstrate the sensitivity of consumption and import forecasts to variations in this variable. A 5 per cent deviation was chosen arbitrarily to acknowledge potential errors and the uncertainty associated with ABARES projection for manufacturing output. **a** Changes in paper and paperboard consumption are based on the estimated model coefficient multiplied by the size of the percentage change in manufacturing. **b** Actual as at May 2012 and may have been revised since.

The forecast for paper and paperboard consumption is sensitive to changes in the value added by manufacturing output. It is important to remember that changes in manufacturing are more likely to affect consumption of packaging and industrial and printing and writing grades of paper. If value added by manufacturing increases by 5 per cent in 2049–50 (from around $129.8 billion to around $136.3 billion), paper and paperboard consumption increases from around 7.08 million cubic metres to 7.37 million cubic metres (Table 17). That is, all other variables being equal, for a 5 per cent increase in manufacturing, paper and paperboard consumption increases by 4.10 per cent.

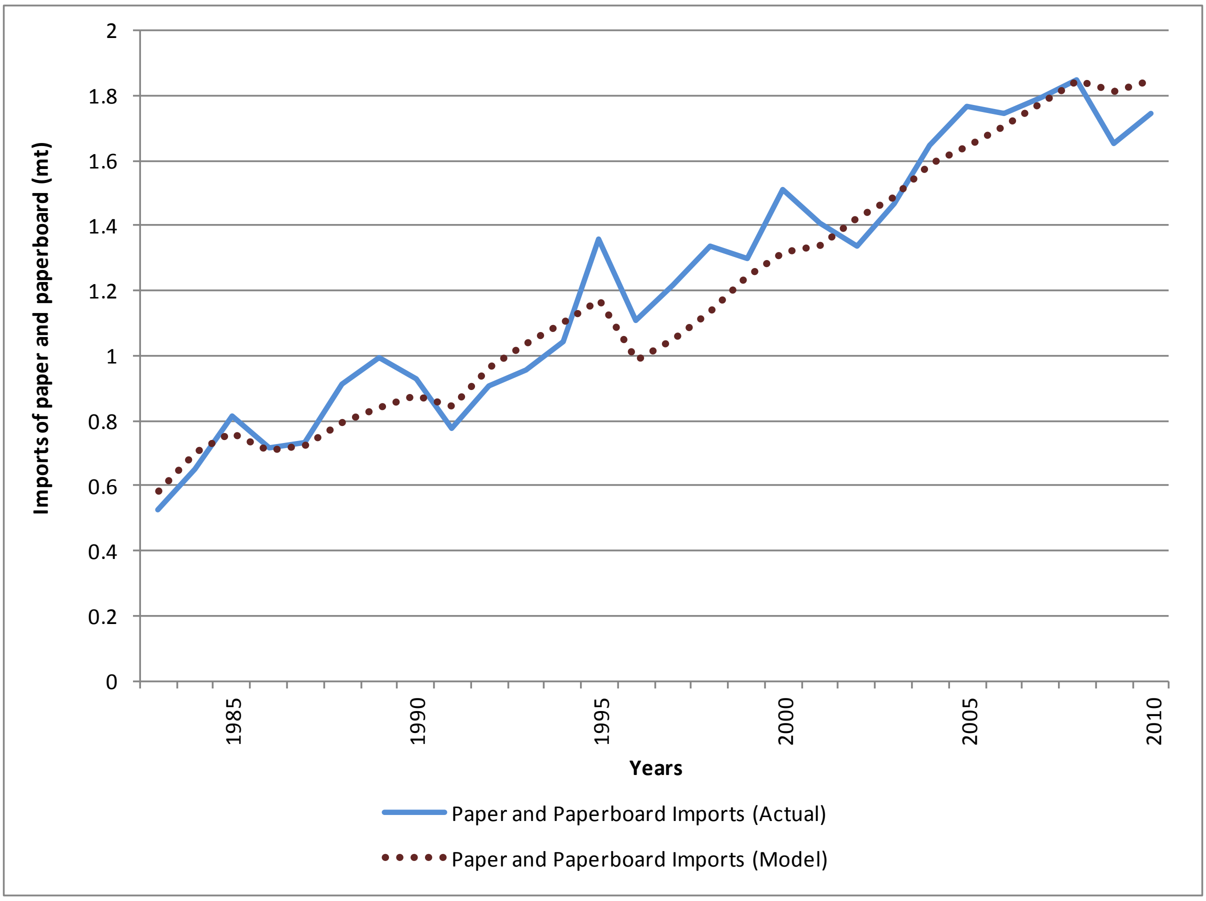
Paper and paperboard imports

Paper and paperboard imports comprise newsprint, household and sanitary paper, packaging and industrial paper and printing and writing paper. ABARES modelled forecasts for the total quantity of paper and paperboard imports for the period 2011–50 using financial year historical data (1983–2010). An econometric model was developed to test the relationship between paper and paperboard imports and the value of GDP product per capita. This variable was used to estimate the relationship between domestic macroeconomic activity and paper and paperboard imports, in lieu of a direct demand factor. Hence, positive or negative changes in real GDP per capita have a corresponding positive or negative effect on paper and paperboard imports.

As with consumption, the wide variety of uses for paper and paperboard products makes estimating aggregate imports difficult. Other domestic supply and demand factors, as well as changes in international markets (particularly the United States which is a major importer of paper and paperboard products), will also affect the volume of imports. Figure 12 shows how well the model fits actual data when backcasting over the period 1983–2010.

Actual paper and paperboard imports during this period is within the constructed 95 per cent confidence interval (which approximately represents two standard errors above and below model estimates) and is followed reasonably well by model estimates. The model does well in imitating the general historical trend but is limited in following directional movement's year-on-year. This is particularly true in the 1990s. Rigorous testing shows that the model is stable and provides accurate forecasts under the assumptions made for the business-as-usual scenario.

Figure 12 Paper and paperboard imports model performance, actual 1983–2010



Source: ABARES models

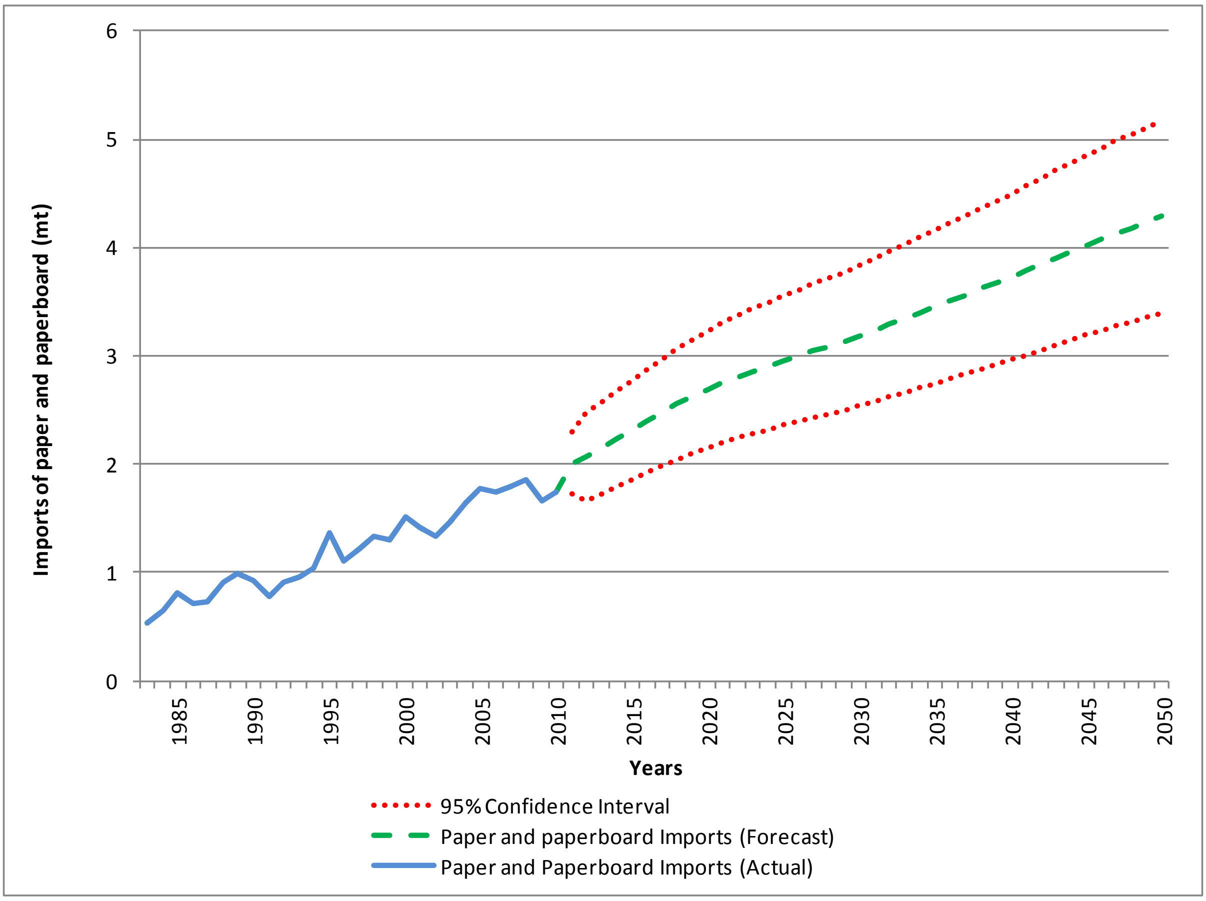
Details of the model structure and assumptions are presented in Appendix A and Appendix B. The forecasts (Figure 13, Table 19) show that the quantity of paper and paperboard imports more than doubles between 2010–11 and 2049–50. The observed trend in paper and paperboard import forecasts is driven by the increasing trend in real GDP per capita based on ABARES projections. The mean quantities of paper and paperboard imports and imports per capita are forecast to increase between 2010–14 and 2045–49. The increase in imports per capita suggests imports of paper and paperboard are growing at a faster rate than population. This arises because paper and paperboard imports are forecast to grow strongly on the basis of the increase in Australia's GDP. The mean proportion of paper and paperboard imports to paper and paperboard consumption is forecast to increase (Table 18). This reflects the assumed decline in contribution of the manufacturing sector to real GDP. As a result, imports of paper and paperboard are forecast to grow faster than consumption.

Table 18 Summary of forecasts for inputs and paper and paperboard imports (annual average), 2010–14, 2030–34 and 2045–49

	Unit	2010–14	2030–34	2045–49
Mean paper and paperboard imports	kt	2 015	3 288	4 127
Mean real gross domestic product per capita	2010A$	60 029	73 742	81 510
Mean paper and paperboard imports per capita	tonnes	0.089	0.111	0.119
Mean proportion of paper and paperboard imports to consumption	%	48.1	55.6	59.8

Source: ABARES forecasts, Australian Government 2011

Figure 13 Paper and paperboard imports, actual 1983–2010, forecast 2010–50



Note: The confidence interval gives a range with 95 per cent certainty for the forecasts under the business-as-usual assumptions. This range is based on the standard errors of forecasts, determined by the modelled relationship between the dependant variable and explanatory variables. Future shocks to explanatory variables and the modelled relationship are not captured by this range.
Source: ABARES forecasts

Range of forecasts

Forecasts show that paper and paperboard imports increase from 1.9 million tonnes in 2010–11 to 3.2 million tonnes in 2029–30 and 4.3 million tonnes in 2049–50 (Table 19). The 95 per cent confidence interval provides a range for the forecasts under the assumptions made for the business-as-usual scenario. However, the range provided by the 95 per cent confidence interval limits the variability of exogenous parameters and does not allow for potential future errors in the assumptions. ABARES estimates that paper and paperboard imports will be between 2.5 million tonnes and 3.8 million tonnes in 2029–30 and between 3.4 million tonnes and 5.2 million tonnes in 2049–50.

Table 19 Forecast summary for paper and paperboard imports

Year	Estimate ’000 tonnes	95 per cent confidence interval ’000 tonnes
2010–11	1 886 **a**	–
2029–30	3 184	± 648
2049–50	4 281	± 890

Note: **a** Actual as at May 2012 and may have been revised since.
Source: ABARES forecasts

7 Woodchip export forecasts

Native and plantation pulplogs in Australia, which represent a primary resource for domestic production of wood products, are harvested for three major uses:

- domestic wood-based panel production
- domestic paper and paperboard production
- woodchip exports.

As a result, exports of woodchips from Australia are affected by the demand for paper and paperboard and wood-based panel products and the future production of these can be expected to influence the level of woodchip exports. The major export destinations are China and Japan and changes in market conditions in these countries can also affect the volume of woodchips exported from Australia. Looking at global supply and demand trends, supply is likely to come from native and plantation hardwood forests in Asia, South America and Africa. Demand will be allocated by global pulp mill capacities and the emergence of potential new markets for these logs such as renewable energy markets in Europe.

In this report, ABARES estimated the volume of paper and panel production and, based on assumed conversion factors listed in Appendix B, calculated approximate estimates of the required pulplogs to meet production needs. Using projections for total availability of pulplogs (ABARES estimates) and subtracting the estimated pulplogs needed for domestic production, provides an estimate for the volume of pulplogs available for woodchip exports. The volume of woodchip exports were then estimated using the conversion factors discussed in Appendix B.

In this report, consumption and imports of paper and paperboard and wood-based panel products in Australia, has been modelled to estimate long-term demand. ABARES estimated the domestic production of these products and consequential domestic pulplog use in two scenarios based on the definition of apparent consumption (equation 1).

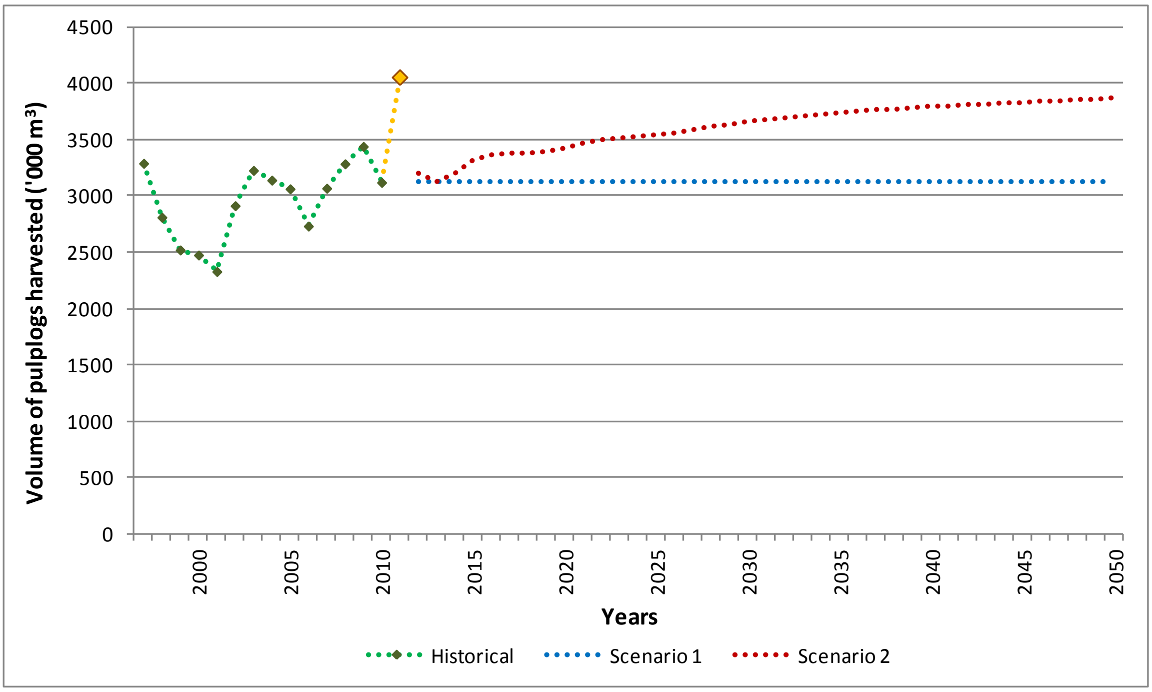
$$Apparent\ Consumption = Production + Imports - Exports \qquad (1)$$

A key factor that will affect the volume of woodchip exports in the future will be domestic demand for pulplogs. Hence future production of pulp and panels will have implications for Australia's projected woodchip exports. The development of new markets for pulplogs, such as bioenergy, will also affect the supply of pulplogs to woodchip export markets. Projections of investment and production of pulp and panels is beyond the scope of this report. However to project the potential volumes of woodchip exports over the outlook period, ABARES has made two simple assumptions regarding future domestic production. The first assumes constant production. Assuming constant production depicts a scenario without further investment in the paper and panel industries. The second uses the consumption and import forecasts presented in this report, together with the definition of apparent consumption, and projects a potential path for future production assuming constant exports. Both scenarios provide an estimate for domestic production of paper and panel products. Based on the conversion factors (Appendix B) the volume of pulplogs needed for domestic use can be approximately determined (Figure 14, Figure 15). The trends for pulplogs used domestically in Scenario 2 generally reflect the forecasts for consumption of wood-based panels and paper and paperboard.

The differences in pulplog types are not considered. Pulplogs available for woodchip exports are then calculated using equation 2.

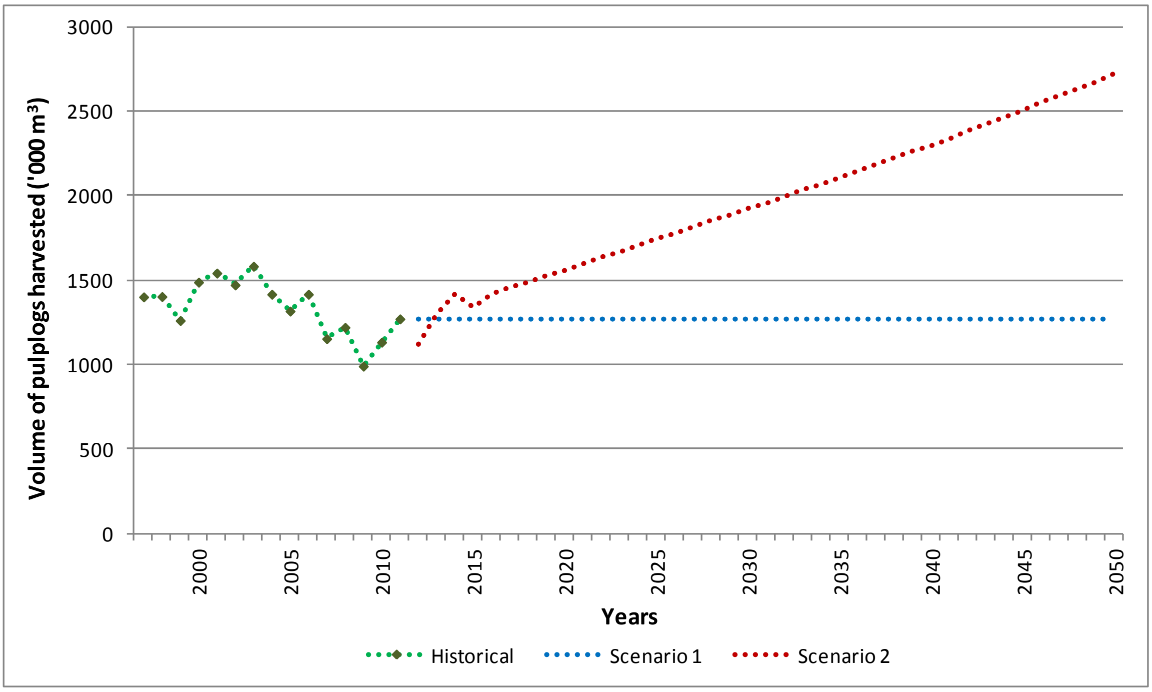
$$Pulplogs\ for\ woodchip\ exports = Total\ pulplog\ harvest - Pulplogs\ used\ domestically \quad (2)$$

Figure 14 Volume of pulplogs harvested for paper and paperboard production; historical 1997–2011, forecasts 2012–50



Note: Scenario 1 assumes constant production. Here the volume of pulplogs harvested for paper production is calibrated to 2009–10 as at the time of this report the estimated volume of pulplogs harvested for paper production in 2010–11 (highlighted in orange) is believed to be an outlier subject to data review. Scenario 2 assumes constant exports.
Source: ABARES forecasts

Figure 15 Volume of pulplogs harvested for wood based panel production; historical 1997–2011, forecasts 2012–50



Note: Scenario 1 assumes constant production. Scenario 2 assumes constant exports
Source: ABARES forecasts

Scenario 1

Scenario 1 assumes no further investment in the paper and paperboard and wood-based panel industries. Hence, domestic production of these products is assumed to stay constant in the forecasting period (2012–50). The ensuing domestic use of pulplogs for both pulp and panel products is estimated to be constant at around 5.3 million cubic metres over the outlook period (Table 20).

Table 20 Forecast summary for pulplogs used for domestic production of paper and paperboard and wood-based panels, 2009–10 to 2049–50

Year	Pulplogs for paper and paperboard production ('000 m^3)	Pulplogs for wood based panel production ('000 m^3)
Current	3 123	1 272
2029–30	3 123	1 272
2049–50	3 123	1 272

Note: Based on 2009–10 estimates for pulplogs harvested for paper and paperboard production and 2010–11 estimates for pulplogs harvested for particleboard and medium density fibreboard production. Plywood production primarily uses sawlogs. The volume of pulplogs harvested for paper production is calibrated to 2009–10 as at the time of this report the estimated volume of pulplogs harvested for paper production in 2010–11 is believed to be an outlier. Consequently, under Scenario 1 assumptions, domestic production of paper is assumed to remain constant from 2010–11 and domestic production of panels constant from 2011–12.

The availability of pulplogs from native and plantation forests is forecast to increase (ABARES estimates). As a result, in this scenario where domestic use of pulplogs stays constant, pulplogs harvested for woodchip exports increases. This implicitly assumes suitable domestic and international economic outlooks, as described in the business-as-usual scenario (Table 1), where markets for Australian woodchip exports provide sufficient returns.

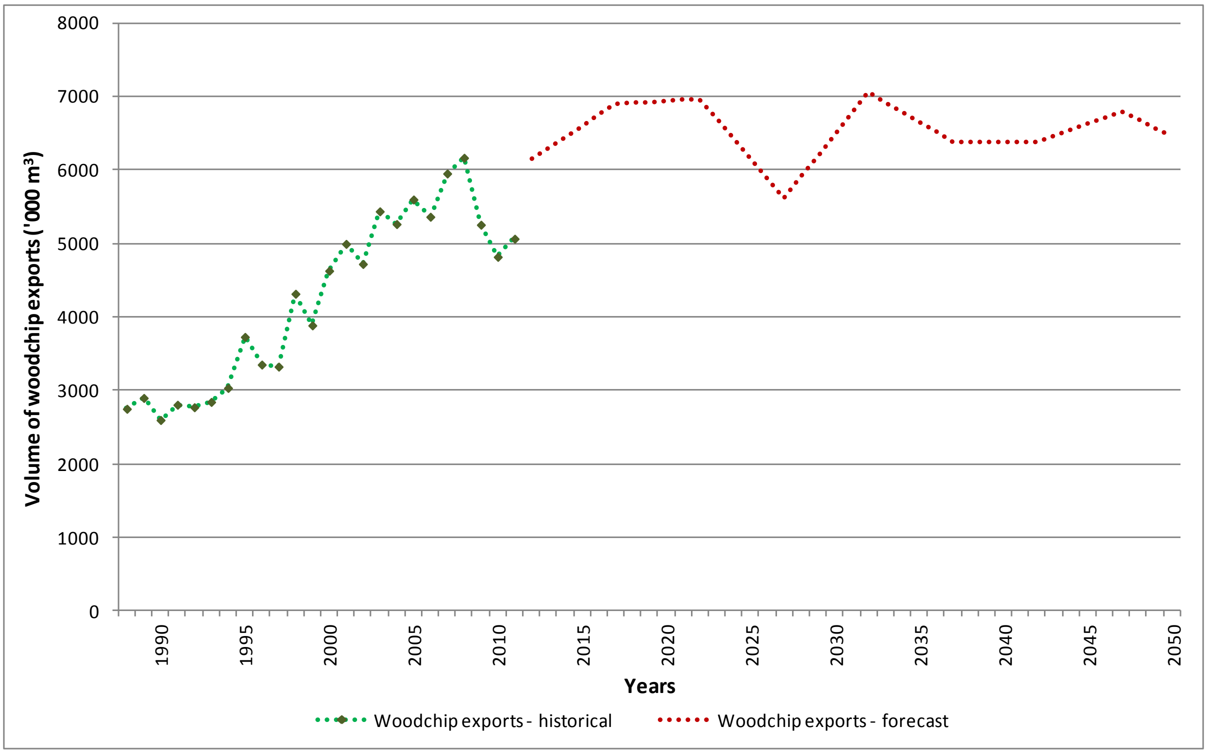
Hence, based on assumed constant domestic demand for pulplogs, the trend in woodchip exports follows the projected availability of pulplogs (Table 21, Figure 16). It is estimated that woodchip exports will increase from 5.1 million cubic metres in 2010–11 to 6.5 million cubic metres in 2029–30 and remain stable thereafter to around 6.5 million cubic metres in 2049–50.

Table 21 Forecast summary for woodchip exports, Scenario 1

Year	Total pulplogs harvested ('000 m^3)	Pulplogs used domestically ('000 m^3)	Pulplogs for woodchip exports ('000 m^3)	Volume of woodchip exports ('000 m^3)
2010–11	14 592 **a**	4 395 **b**	9 235	5 064
2029–30	15 970	4 395	11 575	6 479
2049–50	15 927	4 395	11 532	6 455

Note: **a** The volume of pulplogs harvested includes pulplogs harvested for hardboard which has accounted for a very small percentage of total pulplog harvest over the past decade. **b** Estimates the volume of pulplogs used domestically for production of paper and paperboard, particleboard and medium density fibreboard and does not include pulplogs harvested for domestic production of hardboard.
Source: ABARES forecasts

Figure 16 Woodchip exports, Scenario 1: historical 1988–2011, forecast 2012–50



Source*:* ABARES forecasts

Scenario 2

Scenario 2 examines the implication of consumption and import forecasts for paper and paperboard and wood-based panels. This analysis assumed constant exports over the forecast period (2012–50) and investigated the resulting domestic production based on the apparent consumption definition (equation 1). As a result, this scenario implicitly assumes domestic pulp production changes in line with domestic paper production (that is, there is no change in import share of domestic pulp use), and there is no change to the relative share of inputs such as recycled paper and sawmill residue in domestic pulp production. Table 22 shows results for the volume of pulplogs required for domestic use.

Table 22 Forecast summary for pulplogs used for domestic production of paper and paperboard and wood based panels, 2009–10 to 2049–50

Year	Pulplogs for paper and paperboard production ('000 m³)	Pulplogs for wood based panel production ('000 m³)
Current	3 123	1 272
2029–30	3 657	1 923
2049–50	3 873	2 724

Note: Based on 2009–10 estimates for pulplogs harvested for paper and paperboard production and 2010–11 estimates for pulplogs harvested for particleboard and medium density fibreboard production. Plywood production primarily uses sawlogs. The volume of pulplogs harvested for paper production is calibrated to 2009–10 as at the time of this report the estimated volume of pulplogs harvested for paper production in 2010–11 is believed to be an outlier. Consequently, under Scenario 2 assumptions, domestic production of paper is estimated from 2009–10 and domestic production of panels estimated from 2010–11.

In 2009–10 the ratio of pulplogs harvested for paper and paperboard production (3.1 million cubic metres) to the production of paper and paperboard (3.2 million tonnes) was 0:97, which matches the average ratio over the past decade (from 2000–01 to 2009–10) of 0:97. In 2010–11 the ratio of pulplogs harvested for paper and paperboard production (4.1 million cubic metres) to the production of paper and paperboard (3.2 million tonnes) was 1:29. Therefore, at the time of this report the estimated volume of pulplogs harvested for paper production in 2010–11 is believed to be an outlier.

The mean proportion of imports to consumption is forecast to fall for wood-based panels and increase for paper and paperboard products (Table 13, Table 18). A steady growth in consumption of paper products is met by a higher growth in imports resulting in an increase in the proportion of paper imports to consumption over time. However, in 2010–11 the volume of paper consumption was more than double the volume of paper imports. As a result, in this scenario with constant exports and steady growth in paper consumption, an increase in domestic use of pulplogs for paper production is forecast over the period to 2049–50 (Table 23). Furthermore, the proportion of wood-based panel imports to consumption is forecast to decrease over time thus requiring an increase in domestic production assuming constant exports. The ensuing pulplogs needed for domestic use increase over time and largely follow trends noted in forecasts for consumption and imports of paper and paperboard and wood-based panels (Figure 14, Figure 15).

In this scenario where domestic use of pulplogs is projected to increase, pulplogs harvested for woodchip exports decrease over time. Woodchips and pulplogs are used domestically for producing paper and paperboard and wood-based panels. However, this approach of assuming constant exports and using the definition of apparent consumption is limited as paper and panel production will depend on other factors including investment in processing capacity of mills and domestic log supply. Therefore, this scenario implicitly assumes a domestic economic outlook that facilitates sufficient investment in these industries to meet the required level of domestic production.

It is estimated that woodchip exports will increase from 5.1 million cubic metres in 2010–11 to 5.8 million cubic metres in 2029–30 and decrease to 5.2 million cubic metres in 2049–50 (Figure 17, Table 23). This trend in woodchip exports is primarily driven by the forecast increase in domestic pulplogs available for harvest. There is an overall increase in woodchip exports between 2010–11 and 2029–30 reflecting the growth and trend in pulplogs available for harvest. Between 2029–30 and 2049–50 woodchip exports are forecast to decrease overall. This reflects the combined effect of increased use of pulplogs domestically for production of paper and panel products and overall decrease in pulplogs available for harvest (Table 23).

Table 23 Forecast summary for woodchip exports, Scenario 2

Year	Total pulplogs harvested ('000 m³)	Pulplogs used domestically ('000 m³)	Pulplogs for woodchip exports ('000 m³)	Volume of woodchip exports ('000 m³)
2010–11	14 592 **a**	4 423 **b**	9 235	5 064
2029–30	15 970	5 580	10 390	5 816
2049–50	15 927	6 597	9 329	5 222

Note: **a** The volume of pulplogs harvested includes pulplogs harvested for hardboard which has accounted for a very small percentage of total pulplog harvest over the past decade. **b** Estimates the volume of pulplogs used domestically for production of paper and paperboard, particleboard and medium density fibreboard and does not include pulplogs harvested for domestic production of hardboard.

Source: ABARES forecasts

Figure 17 Woodchip exports, Scenario 2: historical 1988–2011, forecast 2012–50

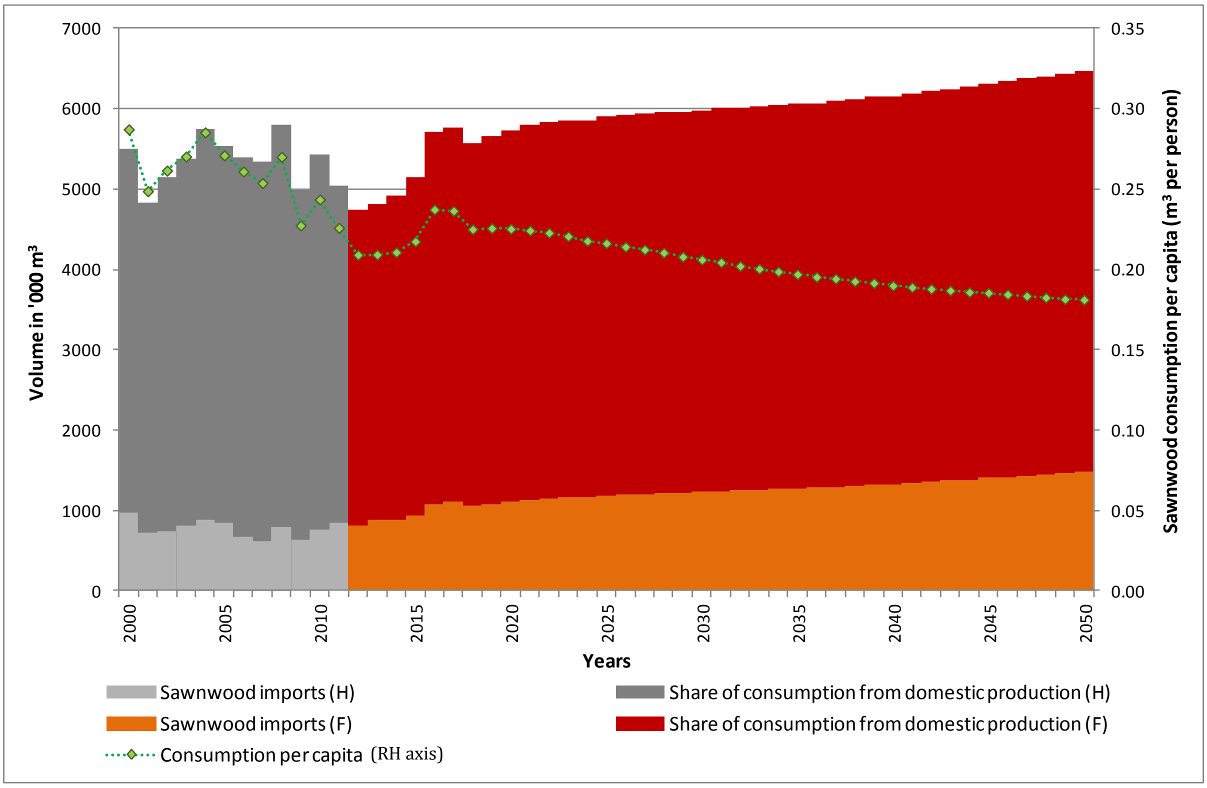
Source: ABARES forecasts

8 Summarising forecasts of consumption and trade

ABARES estimates that sawnwood consumption will continue to increase to 2049–50, although more slowly than consumption of other wood products. This growth will be driven by ongoing growth in detached and multi-dwelling commencements, underpinned by Australia's population growth. Sawnwood consumption is forecast to increase from 5.0 million cubic metres in 2010–11 to 6.0 million cubic metres in 2029–30 and 6.5 million cubic metres in 2049–50.

ABARES preliminary forecasts indicate that sawnwood consumption will continue to increase to 2049–50, albeit more slowly than consumption of other wood products, driven by ongoing growth in detached and multi-dwelling commencements, underpinned by Australia's population growth. Sawnwood consumption is forecast to increase from 5.0 million cubic metres in 2010–11 to 6 million cubic metres in 2029–30 and 6.5 million cubic metres in 2049–50. While sawnwood consumption in Australia declined by an average of 0.5 per cent a year over 2001–11, the forecasts in this report project sawnwood consumption to grow by 0.6 per cent a year on average between 2011–12 and 2049–50 (Figure 18). Sawnwood imports are also forecast to increase, growing by 1.5 per cent a year on average between 2011–12 and 2049–50. This is driven by the rise in multi-dwelling commencements and an assumed stable Australian–US dollar exchange rate. Sawnwood consumption per capita falls over the forecast period and the proportion of sawnwood imports to consumption rises, averaging 22.4 per cent between 2044–45 and 2048–49.

Figure 18 Sawnwood consumption and imports, historical 2000–11, forecasts 2012–50

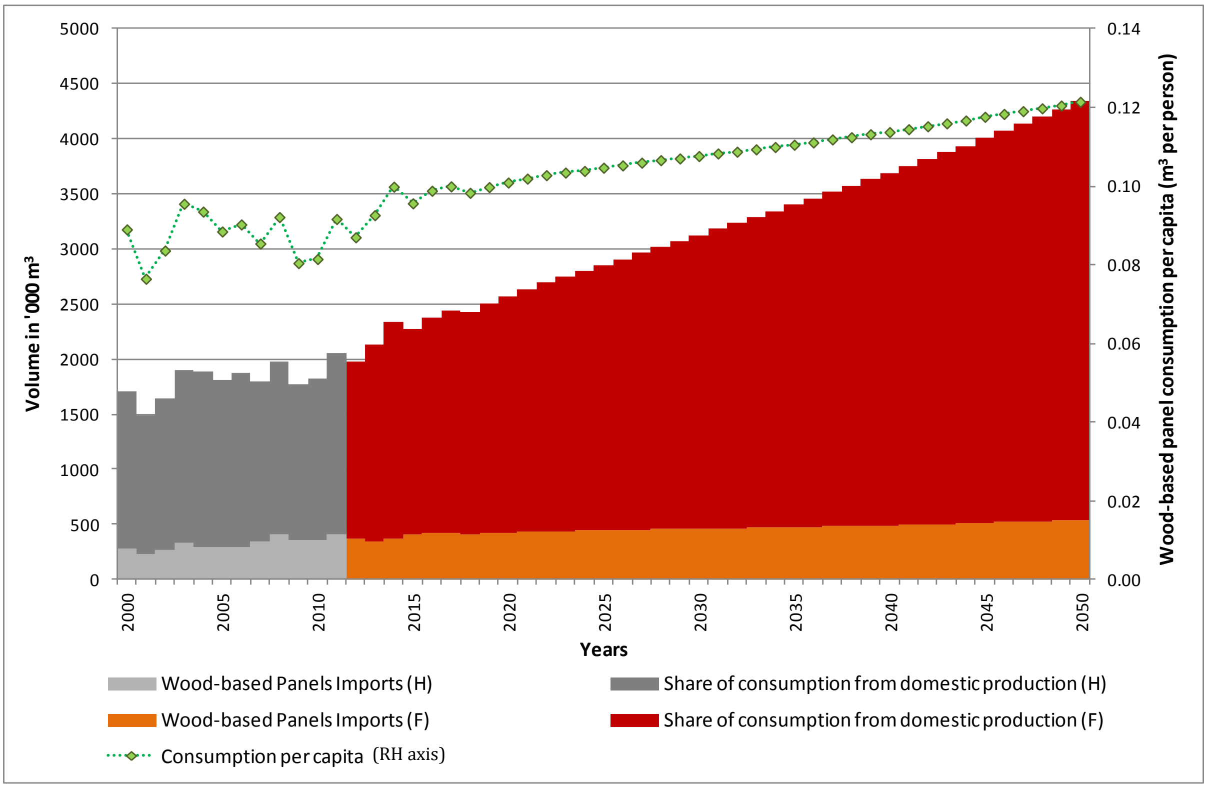


Note: The height of the grey (historical) and red (forecasts) columns represents the total volume of sawnwood consumed (left axis). Historical data (2000–11) for sawnwood imports is shown in light grey. Forecasts (2012–50) for sawnwood imports are shown in orange. Consumption of sawnwood per capita is shown on the right axis in green. The models for

consumption and imports were constructed independently of each other and did not account for the definition of apparent consumption when forecasting. Hence it is not possible to make any inferences for changes in domestic production and exports. It is however possible to conclude that the area in red shows the forecast share of consumption from domestic production to 2049–50.
Source: ABARES forecasts

ABARES estimates that wood-based panel consumption will continue to increase over the forecast period, driven by growth in multi-dwelling commencements and alterations and additions, both of which are underpinned by population growth in capital cities. Consumption of wood-based panels is forecast to increase by an average of 2 per cent a year, from 2.0 million cubic metres in 2010–11 to 3.1 million cubic metres in 2029–30 and 4.3 million cubic metres in 2049–50 (Figure 19). This is lower than historical growth in consumption, which grew by 3.6 per cent a year on average between 2000–01 and 2010–11. Wood-based panel imports are forecast to grow at a slower rate, averaging 0.8 per cent a year between 2010–11 and 2049–50. Wood-based panel consumption per capita rises over the forecast period and the proportion of imports to consumption falls, averaging around 12.4 per cent between 2044–45 and 2048–49.

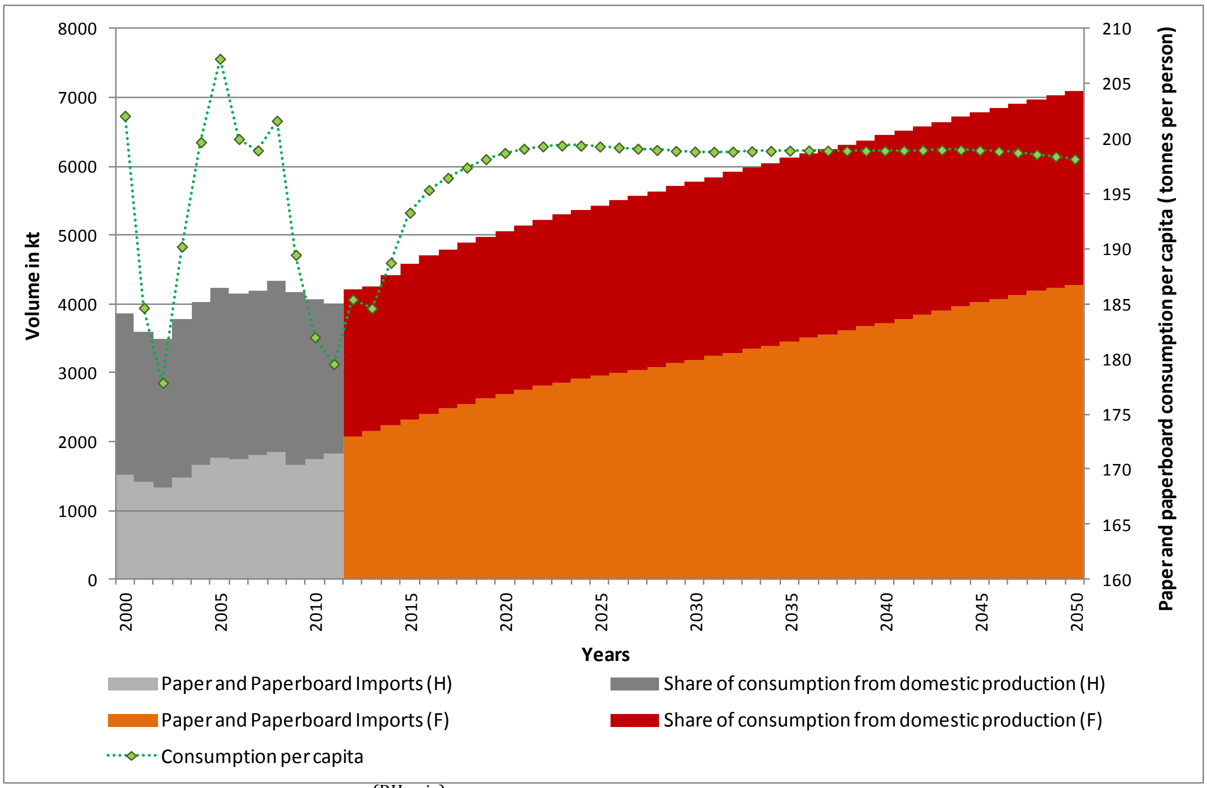
Figure 19 Wood-based panel consumption and imports, historical 2000–11, forecasts 2012–50



Note: The height of the grey (historical) and red (forecasts) columns represents the total volume of wood-based panels consumed (left axis). Historical data (2000–11) for wood-based panel imports is shown in light grey. Forecasts (2012–50) for wood-based panel imports are shown in orange. Consumption of wood-based panels per capita is shown on the right axis in green. The models for consumption and imports were constructed independently of each other and did not account for the definition of apparent consumption when forecasting. Hence it is not possible to make any inferences for changes in domestic production and exports. However, it is possible to conclude that the area in red shows the forecast share of consumption from domestic production to 2049–50.
Source: ABARES forecasts

Paper and paperboard consumption is forecast to grow at a faster rate than imports. ABARES estimates that paper and paperboard consumption will increase from 4.0 million tonnes in 2010–11 to 5.8 million tonnes in 2029–30 (averaging 1.9 per cent a year between 2010–11 and 2029–30) and reaching 7.1 million tonnes in 2049–50 (averaging 1 per cent a year between 2029–30 and 2049–50). These forecasts are based largely on ABARES projections for value added by the manufacturing sector. The manufacturing sector is a large user of packaging and industrial paper and printing and writing paper and represents a domestic demand factor. Growth in paper and paperboard imports is expected to increase marginally from around 2 per cent between 2000–01 and 2010–11 to an average of 2.2 per cent between 2010–11 and 2049–50 (Figure 20). Paper and paperboard consumption per capita rises over the forecast period and the proportion of paper imports to consumption rises averaging around 59.8 per cent between 2044–45 and 2048–49.

Figure 20 Paper and paperboard consumption and imports, historical 2000–11, forecasts 2012–50



Note: The height of the grey (historical) and red (forecasts) columns represents the total volume of paper and paperboard products consumed. Historical data (2000–11) for paper imports is shown in light grey. Forecasts (2012–50) for paper imports are shown in orange. Consumption of paper and paperboard products per capita is shown on the secondary axis in green. The models for consumption and imports were constructed independently of each other and did not account for the definition of apparent consumption when forecasting. Hence it is not possible to make any inferences for changes in domestic production and exports. However, it is possible to conclude that the area in red shows the forecast share of consumption from domestic production to 2049–50.
Source: ABARES forecasts

Consumption per capita is a useful indicator: a stronger growth in consumption of a wood product than in population suggests an increase in use and demand for that product. The results imply an increased demand for wood-based panel and paper and paperboard products. In contrast, while consumption of sawnwood is forecast to increase, consumption per capita is estimated to decrease.

Further, the mean proportion of imports to consumption is forecast to fall for wood-based panels (Table 13) and is forecast to rise for sawnwood and paper and paperboard products between 2011–12 and 2049–50 (Table 8, Table 18). However, import and consumption models have been constructed independently and it is difficult to make inferences for domestic production and export facilities based on these results. The implications of these findings for additional investment in domestic processing capacity will depend on a number of factors, such as future parameters affecting domestic and international processing competitiveness as well as government policies. Domestic investment and processing is not necessarily more efficient, from an economic perspective, than exporting raw materials and importing final products; although they may imply vastly divergent outlooks for Australia's forestry industry, and have different social and environmental implications.

A substantial share of Australia's current wood processing capacity includes woodchip production for export. Forecasts of pulplog availability have been compiled from ABARES publicly available datasets. Based on the estimated growth in pulplog availability, additional domestic infrastructure capacity may be needed for these logs. This investment may result in capacity to process domestically or additional exports of unprocessed logs and woodchips following recent trends in domestic woodchip production. For example, the volume of plantation pulplogs harvested from hardwood forests for woodchip exports has increased by around 31 per cent from 3.6 million cubic metres in 2006–07 to 4.7 million cubic metres in 2010–11. A scenario considered to be an upper bound is examined in this report by assuming constant domestic production of paper and paperboard and wood-based panels (that is, no further investment in capacity to process logs domestically). Under this scenario, woodchip exports are forecast to increase from 5.1 million cubic metres in 2010–11 to 6.5 million cubic metres in 2029–30 (averaging a 1.5 per cent increase per year between 2010–11 and 2029–30) and remain stable thereafter to around 6.5 million cubic metres in 2049–50 (averaging a zero increase per year between 2029–30 and 2049–50). This trend in woodchip exports is primarily driven by the forecast increase in availability and harvest of pulplogs.

An alternative scenario is investigated by assuming constant exports of paper and panel products which allows estimation of domestic production as the gap between forecast consumption and imports. This scenario assumes there is scope for new investment in additional paper and paperboard processing and wood-based panel manufacturing capacity in Australia. Under this scenario, woodchip exports are forecast to increase from 5.1 million cubic metres in 2010–11 to 5.8 million cubic metres in 2029–30 (averaging a 0.9 per cent increase per year between 2010–11 and 2029–30) and decrease to 5.2 million cubic metres in 2049–50 (averaging a 0.5 per cent decline each year between 2030–31 and 2049–50). The trend in woodchip exports is driven by the forecast for total pulplogs harvested and influenced by the volume of pulplogs used for domestic production of paper and panels. Woodchip exports are forecast to fall between 2029–30 and 2049–50 due to growth in consumption of wood-based panels and a decrease in the proportion of imports to consumption. This combined with steady growth in paper and paperboard consumption results in higher domestic panel and paper production and consequently higher domestic demand for pulplogs during a period where pulplogs available for harvest are projected to decrease.

Range of forecasts

Consumption and trade of sawnwood, wood-based panels, paper and paperboard and woodchips is forecast based on business-as-usual assumptions made in this report. The uncertainty associated with these forecasts is largely a function of unaccounted variation as well as variation in modelled factors. This uncertainty is represented by the 95 per cent confidence intervals which provide a range for the forecast with 95 per cent certainty under business-as-usual assumptions. However, as noted in previous caveats, the range provided by the 95 per cent confidence interval limits the variability of exogenous parameters and does not allow for potential future errors in the assumptions.

It is important to acknowledge that business-as-usual assumptions limit the potential variability in factors used in the forecasting models. While the forecast for sawnwood consumption in 2049–50 is 6.5 million cubic metres, the 95 per cent confidence interval suggests a range for this forecast of between 5.5 and 7.4 million cubic metres (Table 24). Similarly, wood-based panel consumption in 2049–50 is forecast to be 4.3 million cubic metres but may range between 3.6 and 5.1 million cubic metres. The housing industry is a large user of structural wood; thus the forecast trend in sawnwood and wood-based panel consumption is primarily driven by dwelling commencements. Paper and paperboard consumption is primarily driven by the value added by the manufacturing sector which is forecast to increase by 20.4 per cent in 2049–50 relative to 2010–11 (ABARES projections discussed in Appendix B). As a result, paper consumption is forecast to be 7.1 million cubic metres in 2049–50, ranging between 6.2 and 8.0 million cubic metres.

Table 24 Summary of forecasts for consumption and trade of selected wood products, 2010–11 to 2049–50

	Units	2010–11	2029–30 f		2049–50 f	
Consumption			**Estimate**	**95% CI**	**Estimate**	**95% CI**
Sawnwood	’000 m³	5 047	5 984	± 831	6 475	± 924
Wood-based panels	’000 m³	2 048	3 126	± 497	4 341	± 715
Paper and paperboard	’000 tonnes	4 012	5 774	± 715	7 083	± 932
Imports						
Sawnwood	’000 m³	846	1 225	± 357	1 481	± 438
Wood-based panels	’000 m³	407	460	± 161	539	± 194
Paper and paperboard	’000 tonnes	1 886	3 184	± 648	4 281	± 890
Exports			**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**
Woodchip exports	’000 m³	5 064	6 479	5 816	6 455	5 222

Note: CI =confidence interval, **f** ABARES forecast

In this report ABARES explored the effect of two scenarios for domestic processing to provide an estimate for woodchip exports. In Scenario 1 no further investment was assumed in domestic processing which led to an increase in the volume of woodchip exports over the forecast period. In Scenario 2 woodchips are increasingly used domestically with an expansion in the domestic processing of paper products and manufacturing of panel products, leading to a decline in the volume of woodchip exports over the forecast period.

As demonstrated by these restricted scenarios, a number of factors need to be taken into account when analysing potential investment in processing capacity and domestic use of pulplogs over time. Many factors can affect domestic investment and production decisions and will have implications for viability of harvesting logs for woodchips compared with other uses. These forecasts would be different for alternative assumptions about:

- production of paper, pulp and panels in Australia

- substitution of logs with other fibres
- opportunities for alternative markets such as bioenergy.

Other issues not considered in this analysis include changes to overseas demand for Australian woodchips and long-term social and environmental values. Future research in forecasting the long-term outlook for Australia's forestry industry could examine these considerations and assess the potential domestic processing capacity of Australia's forecast log availability.

Further research

In this report, ABARES analysed consumption and imports of wood products and highlighted broad trends across the forestry sector. However, more sophisticated analysis of domestic production is needed to adequately assess the long-term implications of the forecast surplus in log availability. In particular, whether log availability could translate into additional investments in domestic processing capacity would depend on a number of factors that need to be considered within a comprehensive modelling framework.

Further ABARES research could include investigation of additional explanatory variables in the econometric models, and breakdown of commodity forecasts into their detailed components. A reduced form econometric analysis could also be examined to create a model structure wherein the level of consumption implicitly helps determine the level of imports. In future research ABARES could also integrate consumption and trade forecasts with FORUM to produce regional estimates of wood products output and investment over the forecast period. The log equivalent consumption implied by the forecasts in this report can also be explored. Combined with the outputs of FORUM, a comparison with projections for availability of different sawlog and pulplog grades could provide insights to trends in production of different commodity groups. This comparison could also provide a better understanding of the importance of trade. While Australia's forecast log availability may exhibit substantial growth in some areas, existing processing capacity may not be sufficient to process larger log volumes. Future research using FORUM could assess the economic potential for investments in processing capacity over time, taking into account the availability of timber as well as the volume of imports.

Future analysis could also include development and modelling of alternative outlook scenarios for the forestry sector. These scenarios could include sets of assumptions that define alternative futures for Australia's wood product industries, different assumptions for economic and population growth, regulations and market incentives for investments in timber resources and processing infrastructure, and demand conditions for wood products.

Appendix A: Econometric models for consumption and trade of wood products

ABARES has, for many years, produced short-term forecasts of sawnwood, wood-based panels and paper and paperboard for its *Agricultural Commodities* report, as well as ad hoc forecasts for specific research reports (such as Love et al. 1999). The *Agricultural Commodities* forecasts are undertaken using a simplified approach, based on aggregate commodity groups (sawnwood and wood-based panels and paper and paperboard). These forecasts have generally focused on exports and imports primarily using trend analysis to estimate unit values and the value of trade flows and are informed by some econometric modelling of the volume of trade.

As part of this report, ABARES developed a long-term econometric forecasting methodology, jointly funded by Forest and Wood Products Australia (FWPA) and ABARES, that represents a more comprehensive and sophisticated approach more closely aligned to that taken in the ad hoc research reports such as Love and colleagues (1999). The current approach involved setting up regression models for consumption of wood products, which estimate the relationships between dependent variables and the respective factors that help determine them (independent/explanatory variables). These models were estimated using the econometric and forecasting software, EViews. Historical data for consumption is calculated using the definition of apparent consumption. The apparent consumption of wood products is calculated as:

$$Apparent\ consumption = Production + Imports - Exports$$

For the present analysis, the consumption forecasting models encompass a 39-year time horizon from 2011–12 to 2049–50. The present forecasting research also includes development of wood product trade models, which employ more comprehensive frameworks, as discussed in this appendix, than currently used for the *Agricultural Commodities* forecasts. Given the relationship between consumption and imports, the trade models would ideally incorporate the definition of apparent consumption using a reduced form econometric analysis to determine imports as described in Appendix C. However, as outlined in Appendix C, this approach requires an exogenous projection for production and exports. Future research and analysis using FORUM may test this methodology in greater detail.

It is worth mentioning the difference between the economic model and the econometric model discussed in this appendix. The economic model is a hypothesis that looks at a number of variables that may help forecast the dependent variable. These variables were extensively tested and either included or discarded in the econometric model. The econometric model is the result of considerable testing of hypothesised variables and includes variables to account for business cycle components and outliers or influential points in the data. Prices while hypothesised to explain the volume of consumption and imports were not included in the modelling process due to limited reliability and availability of data.

Sawnwood and wood-based panels

Methodology

It is expected that consumption of structural timber is primarily a function of housing starts and other macroeconomic variables. Given that a significant percentage of sawnwood and wood-based panel consumption is used for structural purposes, detached and multi-dwelling housing starts and alterations or additions to existing homes (or renovations) are likely to be the major demand factors in the consumption model. However, housing starts and renovations alone may be insufficient to fully explain wood consumption levels during economic contractions or business cycles. Macroeconomic variables such as real GDP per capita, home loan interest rates and population growth or variables accounting for dynamic patterns such as auto-regressive or moving average terms may also affect the forecasts of consumption and trade.

The forecasts for imports are likely to be affected by domestic demand in Australia and may additionally depend on macroeconomic variables for Australia's major trading partners. The import model may also be influenced by domestic/world GDP growth and world prices.

ABARES developed a set of econometric models to project domestic consumption of sawnwood and wood-based panels. Development of these models involved identifying the factors likely to affect timber consumption, and regression analysis of these variables. The full potential of the constructed models lies in estimating consumption until 2050, thereby providing a long-term picture of the market and direction for the sawnwood and panels industries.

The hypothesis for the economic model is that sawnwood consumption is a function of housing starts and other macroeconomic variables. The econometric model, based on rigorous testing, may take some or all of these variables into account.

$$swc = f(\mathrm{DD}, \mathrm{MD}, \mathrm{RGDPP}, \mathrm{HINT}, \mathrm{POP}, \mathrm{HINC})$$

Where:

- *swc* is total consumption of sawnwood (hardwood sawnwood and softwood sawnwood)
- DD is commencements of detached dwellings
- MD is commencements of multi-dwellings
- RGDPP is real gross domestic product per capita
- HINT is home loan interest rates
- POP is population
- HINC is household income.

The economic model for wood-based panel consumption was hypothesised to be a function of housing starts, the value of renovations and other macroeconomic variables. It is expected that wood-based panel consumption is primarily for use in multi-dwelling commencements. The econometric model, based on rigorous testing, may take some or all of these variables into account.

$$\mathrm{w}bpc = f(\mathrm{MD}, \mathrm{RENO}, \mathrm{RGDPP}, \mathrm{HINC})$$

Where:

- *wbpc* is total consumption of wood-based panels (plywood, particleboard and medium density fibreboard)
- MD is commencements of multi-dwellings
- RENO is value of renovations
- RGDPP is real gross domestic product per capita
- HINC is household income.

ABARES also developed a set of econometric models to forecast imports of sawnwood and wood-based panels. Development of these models relies primarily on domestic demand factors, macroeconomic factors and moving average terms accounting for dynamic patterns. This analysis significantly improves past forecast methodologies for the *Agricultural Commodities* report. Previous reports (including Love et al. 1999) did not fit econometric models for estimation of trade. As with consumption, the full potential of this analysis lies in estimating imports to 2050.

The economic model hypothesised for sawnwood imports was a function of housing starts and some domestic and international macroeconomic factors. The econometric model, based on rigorous testing, may take some or all of these variables into account.

New Zealand's real GDP per capita was included in the hypothesis as New Zealand is one of Australia's key trading partners for wood products. Trends in New Zealand's economy can play a role in determining trade and hence consumption in Australia.

$$swi = f(\mathrm{DD}, \mathrm{MD}, \mathrm{RGDPP}, \mathrm{POP}, \mathrm{USEX}, \mathrm{NZRGDPP})$$

Where:

- *swi* is imports of sawnwood
- DD is commencements of detached dwellings
- MD is commencements of multi-dwellings
- RGDPP is Australia's real gross domestic product per capita
- POP is population
- USEX is Australian to US dollar exchange rate
- NZRGDPP is New Zealand's real gross domestic product per capita.

In a similar fashion, wood-based panel imports were hypothesised to be a function of housing starts and macroeconomic variables. The econometric model, based on rigorous testing, may take some or all of these variables into account.

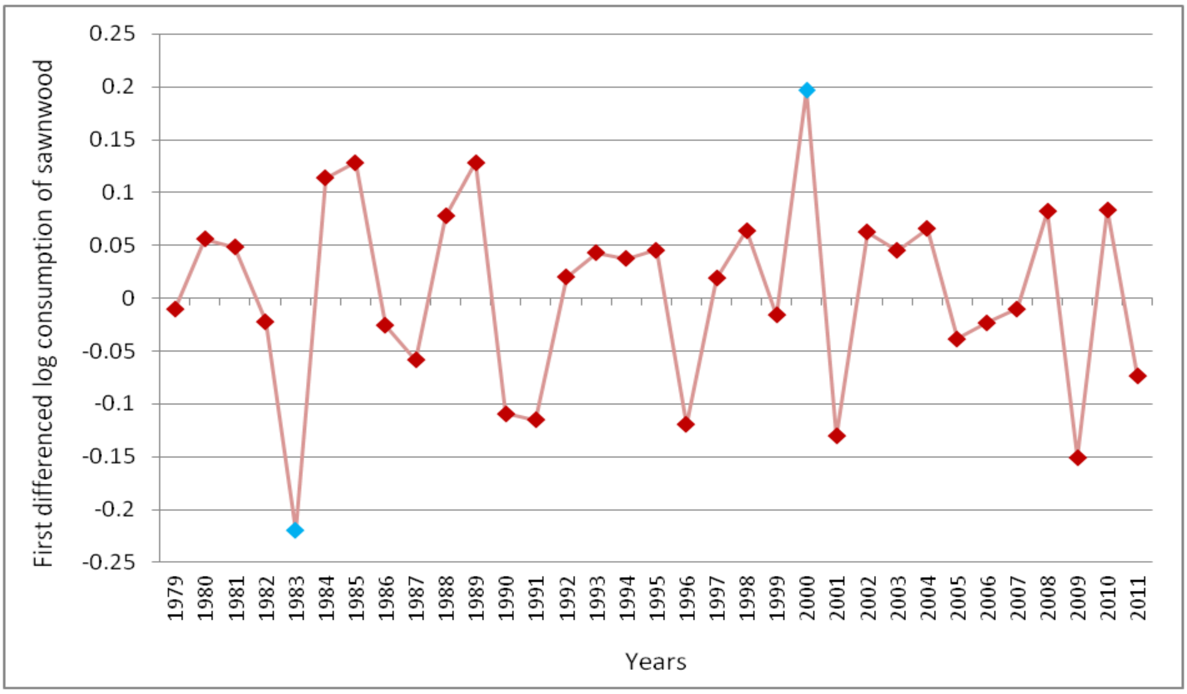
$$\mathrm{w}bpi = f(\mathrm{MD}, \mathrm{RENO}, \mathrm{RGDPP}, \mathrm{POP}, \mathrm{USEX})$$

Where:

- *swi* is imports of sawnwood
- MD is commencements of multi-dwellings
- RENO is value of renovations
- RGDPP is Australia's real gross domestic product per capita
- POP is population
- USEX is Australian to US dollar exchange rate.

Possible time trend, stationarity and increasing volatility issues were considered and tested using the auto-correlation function (ACF), Partial ACF and Augmented Dickey Fuller (ADF) tests. On completion of these tests it was found that unit root issues were present in most variables requiring us to take the first difference of the data. Further, the log of all variables was taken to enable additional interpretation of coefficients. Two potential outliers in the data, in 1983 (due to a significant drought) and in 2000 (due to imminent introduction of the Goods and Services Tax or GST) were found with varying effects on the identified variables (Figure A1).

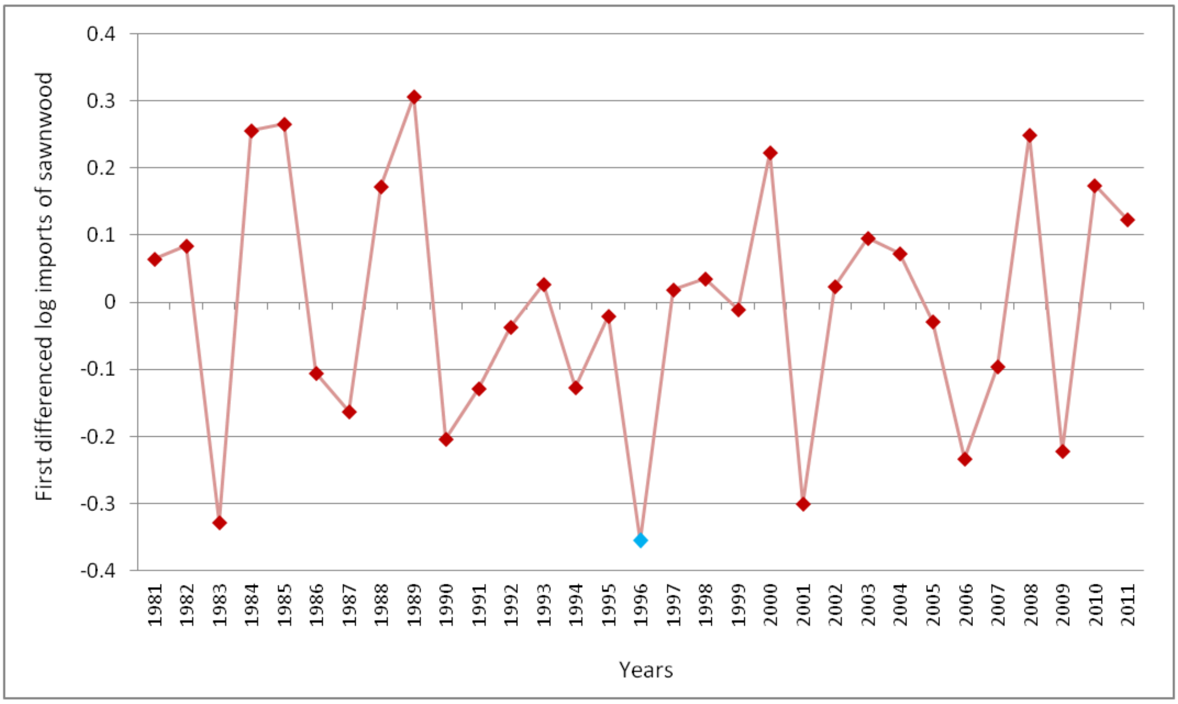
Figure A1 First differenced log of sawnwood consumption, 1978–2011



Source: ABARES datasets

Sawnwood may have an outlier in the quantity of imports in 1996 that is unexplained by the independent variables (Figure A2). This particular slump may in part be due to shocks in the North American timber market with the northern spotted owl listed as threatened under the United States Endangered Species Act (Majumdar et al. 2010).

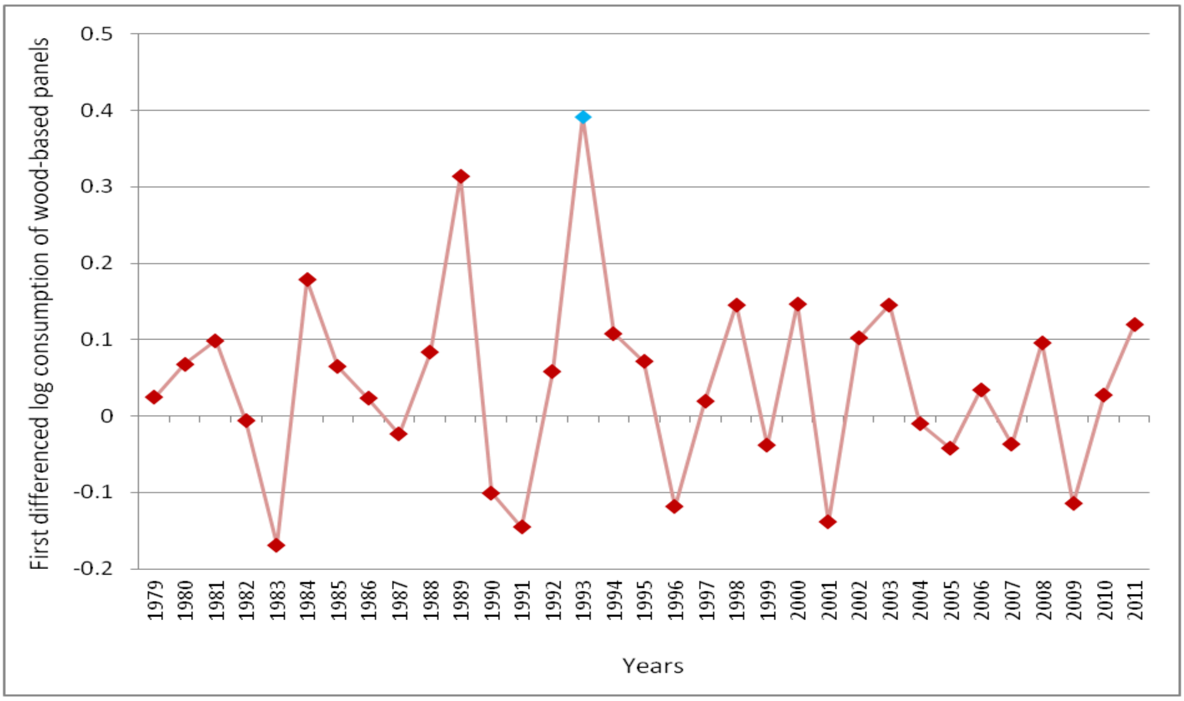
Figure A2 First differenced log of sawnwood imports, 1990–2011



Source: ABARES datasets

A potential outlier in wood-based panel consumption was found in 1993 when medium density fibreboard consumption was first recorded in Australia (Figure A3).

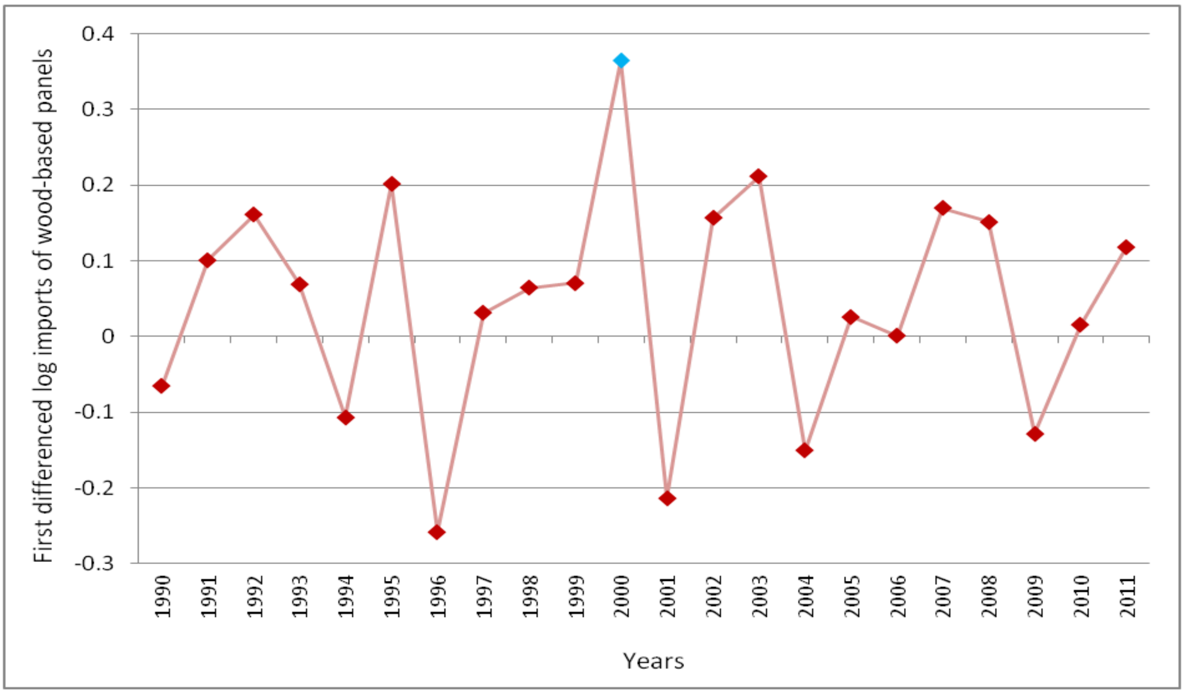
Figure A3 First differenced log of wood-based panel consumption, 1990–2011



Source: ABARES datasets

A potential outlier in wood-based panel import quantities was found in 2000 just before the GST was introduced in Australia (Figure A4).

Figure A4 First differenced log of wood-based panel imports, 1990–2011



Source: ABARES datasets

The consumption and trade forecasting model used ordinary least squares (OLS) methods as there was no evidence to suggest a need for non-linear least squares. This follows the same procedure as that of Love and colleagues (1999) and Hossain and colleagues (1989) who both used OLS estimation, forecasting approximately 40 years. In this report the structure of the models has been improved to avoid challenges faced by earlier reports and better model the dynamic and business cycle components of the data.

Econometric results

Sawnwood consumption

$$d(\log(swc)) = 0.124d(\log(dd)) + 0.317d(\log(md)) + 0.163D00$$

$$(0.049) \qquad (0.048) \qquad (0.024)$$

$$-0.093D02 - 0.87MA(5)$$

$$(0.026) \qquad (0.052)$$

$$R^2_{adj} = 0.895, S.E\ of\ Regression = 0.03$$

Where:

- swc is sawnwood consumption in thousand cubic metres
- dd is the number of detached dwellings commenced
- md is the number of multi-dwellings commenced
- d00 and d02 are dummy variables for 2000 and 2002
- MA is a moving average term.

The purpose of the model is to establish and test the hypothesised relationship between the number of detached and multi-dwellings commenced and sawnwood consumption. Hence, specific outliers in consumption were separated to observe the effect of dwelling commencements on sawnwood consumption.

The model was constructed on first differenced log data. A dummy variable was used for an outlier in consumption levels in 2000 when the goods and services tax (GST) was introduced to Australia. A dummy variable in 2002 reflects a significant increase in detached and multi-dwelling commencements following the temporary slump in 2000–01 following introduction of the GST. The moving average term accounts for dynamic patterns in consumption between 1979 and 2011 which are assumed to continue to 2050.

The fitted model follows actual data accurately and within a 95 per cent confidence interval. The model was tested for stability in residuals and forecasts. It appears stable with a high adjusted R-squared value, significant explanatory variables and consistent t-statistics (Table A1). While the Durbin–Watson statistic is low, rigorous testing indicates stability in the residuals with no detection of serial correlation or heteroskedasticity issues. Tests were also undertaken for multicollinearity and co-integration with negative results.

Table A1 Sawnwood consumption model: EViews output

Dependent Variable: D(LOG(SWC))
Method: Least Squares
Sample (adjusted): 1979 2011
Included observations: 33 after adjustments
Convergence achieved after 15 iterations
MA Backcast: 1974 1978

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(DD))	0.124276	0.048657	2.554152	0.0164
D(LOG(MD))	0.317249	0.048035	6.604555	0.0000
D00	0.162751	0.023835	6.828138	0.0000
D02	-0.092510	0.026455	-3.496935	0.0016
MA(5)	-0.869993	0.051647	-16.84483	0.0000

R-squared	0.908434	Mean dependent var	0.005943
Adjusted R-squared	0.895353	S.D. dependent var	0.091706
S.E. of regression	0.029666	Akaike info criterion	-4.058889
Sum squared resid	0.024642	Schwarz criterion	-3.832146
Log likelihood	71.97168	Hannan-Quinn criter.	-3.982597
Durbin-Watson stat	1.299795		

Inverted MA Roots	.97	.30-.92i	.30+.92i	-.79+.57i
	-.79-.57i			

The model estimated in EViews suggests a positive coefficient for multi-dwelling and detached dwelling commencements (explanatory variables). Therefore a positive change in the explanatory variables results in a corresponding positive change in the quantity of sawnwood consumption. The coefficients in the model estimate the extent of the change. As these models are constructed in first difference logs, the coefficient approximates a percentage change. Specifically, a 1 per cent increase in detached or multi-dwelling commencements is estimated to result in a 0.12 per cent and 0.32 per cent increase in sawnwood consumption, respectively.

Sawnwood imports

$$d(\log(swi)) = 0.741d(\log(md)) + 0.324d(\log(us_{ex}))$$

$$(0.132) \qquad (0.186)$$

$$-0.153D96 - 0.912MA(6)$$

$$(0.066) \qquad (0.036)$$

$$R^2_{adj} = 0.891, S.E\ of\ Regression = 0.054$$

Where:

- swi is sawnwood imports in thousand cubic metres
- md is the number of multi-dwellings commenced
- us_{ex} is the Australian to US dollar exchange rate
- D96 is a dummy variable for 1996
- MA is a moving average term.

The purpose of the model is to establish and test the hypothesised relationship between the number of multi-dwelling commencements, the Australian to US dollar exchange rate and sawnwood imports. Hence, specific outliers in imports were separated to observe the effect of the explanatory variables on sawnwood imports. The model was constructed on first differenced log data. A dummy variable was used for outlying import levels in 1996. It is possible that this reflects a restructuring of imports from the North American region due to environmental regulations implemented around this time.

The moving average term accounts for dynamic patterns in imports between 1990 and 2011 which are assumed to continue to 2050.

The fitted model follows the actual data accurately and within a 95 per cent confidence interval. The model was tested for stability in residuals and forecasts. It appears stable with good adjusted R-squared value, significant explanatory variables, consistent t-statistics and Durbin–Watson statistic (Table A2). Testing further shows stability in the residuals with no detection of serial correlation or heteroskedasticity. Tests were also undertaken for multicollinearity and co-integration with negative results.

Table A2 Sawnwood imports model: EViews output

Dependent Variable: D(LOG(SWI))
Method: Least Squares
Sample (adjusted): 1990 2011
Included observations: 22 after adjustments
Convergence achieved after 9 iterations
MA Backcast: 1984 1989

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(MD))	0.740904	0.131906	5.616914	0.0000
D(LOG(US_EX))	0.323939	0.185682	1.744591	0.0981
D96	-0.153216	0.065732	-2.330935	0.0316
MA(6)	-0.911921	0.036484	-24.99510	0.0000

R-squared	0.906147	Mean dependent var	-0.032365
Adjusted R-squared	0.890505	S.D. dependent var	0.162795
S.E. of regression	0.053869	Akaike info criterion	-2.841560
Sum squared resid	0.052234	Schwarz criterion	-2.643189
Log likelihood	35.25716	Hannan-Quinn criter.	-2.794830
Durbin-Watson stat	1.724113		

Inverted MA Roots	.98	.49-.85i	.49+.85i	-.49-.85i
	-.49+.85i	-.98		

The model estimated in EViews suggests a positive coefficient for multi-dwelling commencements and the Australian to US dollar exchange rate (explanatory variables). Therefore a positive change in the explanatory variables results in a corresponding positive change in the quantity of sawnwood imports. The coefficients in the model estimate the extent of the change. As these models are constructed in first difference logs, the coefficient approximates a percentage change. Specifically, a 1 per cent increase in multi-dwelling commencements or Australian to US dollar exchange rates is estimated to result in a 0.74 per cent and 0.32 per cent increase in sawnwood imports, respectively.

Wood-based panel consumption

$$d(\log(wbpc)) = 0.482d(\log(reno)) + 0.263d(\log(md)) + 0.098D89$$

$$(0.053) \qquad (0.038) \qquad (0.045)$$

$$+0.25D93 - 0.877MA(4)$$

$$(0.039) \qquad (0.036)$$

$$R^2_{adj} = 0.907, S.E\ of\ Regression = 0.038$$

Where:

- $wbpc$ is wood-based panel consumption in thousand cubic metres
- md is the number of multi-dwellings commenced
- $reno$ is the value of approved alterations and additions to existing dwellings in thousands of 2010 Australian dollars
- D89 and D93 are dummy variables for 1989 and 1993
- MA is a moving average term.

The purpose of the model is to establish and test the hypothesised relationship between number of multi-dwellings commenced, value of renovations and wood-based panel consumption. Hence, specific outliers in consumption were separated to observe the effect of these factors on wood-based panel consumption.

The model was constructed on first differenced log data. A dummy variable for outlying consumption levels was used in 1989. This coincides with deregulation of financial markets in Australia and a false recovery from recession in 1987. A dummy variable was also used for consumption levels in 1993. This accounts for the increase in wood-based panel consumption levels when medium density fibreboard consumption was first estimated in Australia.

The fitted model follows the actual data accurately and within a 95 per cent confidence interval. The model was tested for stability in residuals and forecasts. It appears stable with a high adjusted R-squared value, significant explanatory variables, consistent t-statistics and Durbin–Watson statistic (Table A3). Testing further shows stability in the residuals with no detection of serial correlation or heteroskedasticity. Tests were also undertaken for multicollinearity and co-integration with negative results.

Table A3 Wood-based panels consumption model: EViews output

Dependent Variable: D(LOG(WBPC))
Method: Least Squares
Sample (adjusted): 1979 2011
Included observations: 33 after adjustments
Convergence achieved after 11 iterations
MA Backcast: 1975 1978

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(RENO))	0.481512	0.052704	9.136079	0.0000
D(LOG(MD))	0.263182	0.037788	6.964722	0.0000
D89	0.097721	0.045229	2.160588	0.0394
D93	0.249939	0.039017	6.405863	0.0000
MA(4)	-0.877220	0.036440	-24.07310	0.0000

R-squared	0.918739	Mean dependent var	0.041752
Adjusted R-squared	0.907131	S.D. dependent var	0.123093
S.E. of regression	0.037512	Akaike info criterion	-3.589580
Sum squared resid	0.039400	Schwarz criterion	-3.362836
Log likelihood	64.22806	Hannan-Quinn criter.	-3.513287
Durbin-Watson stat	2.052249		

Inverted MA Roots	.97	.00-.97i	-.00+.97i	-.97

The model estimated in EViews suggests a positive coefficient for both multi-dwelling commencements and the value of renovations. Therefore a positive change in explanatory variables results in a corresponding positive change in quantity of wood-based panels consumed. The coefficients in the model estimate the extent of the change. As these models are constructed in first difference logs, the coefficient approximates a percentage change. Specifically, a 1 per cent increase in multi-dwelling commencements results in a 0.26 per cent increase in the rate of growth in wood-based panel consumption. Similarly, a 1 per cent increase in the value of renovations results in a 0.48 per cent increase in wood-based panel consumption.

Wood-based panel imports

$$d(\log(wbpi)) = 0.618\, d(\log(md)) + 0.225D95 + 0.26D00$$

$$(0.082) \qquad (0.094) \qquad (0.080)$$

$$+0.186D07 - 0.878MA(5)$$

$$(0.071)\ (0.042)$$

$$R^2_{adj} = 0.772, S.E\ of\ Regression = 0.072$$

Where:

- $wbpi$ is wood-based panel imports in thousand cubic metres
- md is the number of multi-dwellings commenced
- D95, D00 and D07 are dummy variables for 1995, 2000 and 2007
- MA is a moving average term.

The purpose of the model is to establish and test the hypothesised relationship between the number of multi-dwellings commenced and wood-based panel imports. Hence, specific outliers in imports were separated to observe the effect of these factors on wood-based panel imports.

The model was constructed on first differenced log data. Dummy variables for outliers in the quantity of imports were used in 1995, 2000 and 2007. The moving average term accounts for dynamic patterns in imports between 1990 and 2011 which are assumed to continue to 2050.

The fitted model follows the actual data accurately and within a 95 per cent confidence interval. The model was tested for stability in residuals and forecasts. It appears stable with an acceptable adjusted R-squared value, significant explanatory variables, consistent t-statistics and Durbin–Watson statistic (Table A4). Testing further shows stability in the residuals with no detection of serial correlation or heteroskedasticity. Tests were also undertaken for multicollinearity and co-integration with negative results.

The model estimated in EViews suggests a positive coefficient for the number of multi-dwellings commenced (explanatory variable). Therefore a positive change in the explanatory variable results in a corresponding positive change in the quantity of wood-based panels imported. The coefficients in the model estimate the extent of the change. As these models are constructed in first difference logs, the coefficient approximates a percentage change. Specifically, a 1 per cent increase in multi-dwelling commencements is estimated to result in a 0.62 per cent increase in wood-based panel imports.

Table A4 Wood-based panel imports model: EViews output

Dependent Variable: D(LOG(WBPI))
Method: Least Squares
Sample (adjusted): 1990 2011
Included observations: 22 after adjustments
Convergence achieved after 12 iterations
MA Backcast: 1985 1989

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(MD))	0.618372	0.082179	7.524714	0.0000
D00	0.259966	0.079933	3.252300	0.0047
D07	0.186067	0.070709	2.631447	0.0175
D95	0.224612	0.094049	2.388256	0.0288
MA(5)	-0.878317	0.042423	-20.70379	0.0000

R-squared	0.815324	Mean dependent var	0.045131
Adjusted R-squared	0.771871	S.D. dependent var	0.151685
S.E. of regression	0.072449	Akaike info criterion	-2.215154
Sum squared resid	0.089230	Schwarz criterion	-1.967189
Log likelihood	29.36669	Hannan-Quinn criter.	-2.156741
Durbin-Watson stat	2.194668		

Inverted MA Roots	.97	.30-.93i	.30+.93i	-.79+.57i
	-.79-.57i			

Paper and paperboard

Methodology

ABARES identified the range of potential factors affecting long-term consumption and import of paper and paperboard based on economic theory and a literature review of similar studies. Although the models described in this report provide forecasts for consumption and import of aggregate paper and paperboard, rather than individual paper grades, ABARES considered the factors affecting these components in estimating the drivers of total consumption and trade.

ABARES developed a set of econometric models to project domestic consumption and imports of paper and paperboard. Development of these models involved identifying a primary demand variable and other macroeconomic variables likely to affect consumption and trade, and regression analysis of these variables. The full potential of the constructed models lies in estimating consumption and imports until 2050, thereby providing a more complete picture of the market and direction for the paper and paperboard industry.

Paper and paperboard consumption and imports were hypothesised to be a function of the value of the output of the manufacturing sector in Australia and other macroeconomic variables. The econometric model, based on rigorous testing, may take some or all of these variables into account.

$$ppbc = f(\text{MANF}, \text{RGDPP}, \text{POP}, \text{CINC})$$

$$ppbi = f(\text{MANF}, \text{RGDPP}, \text{PRICE}_{\text{WORLD}}, \text{USRGDPP})$$

Where:

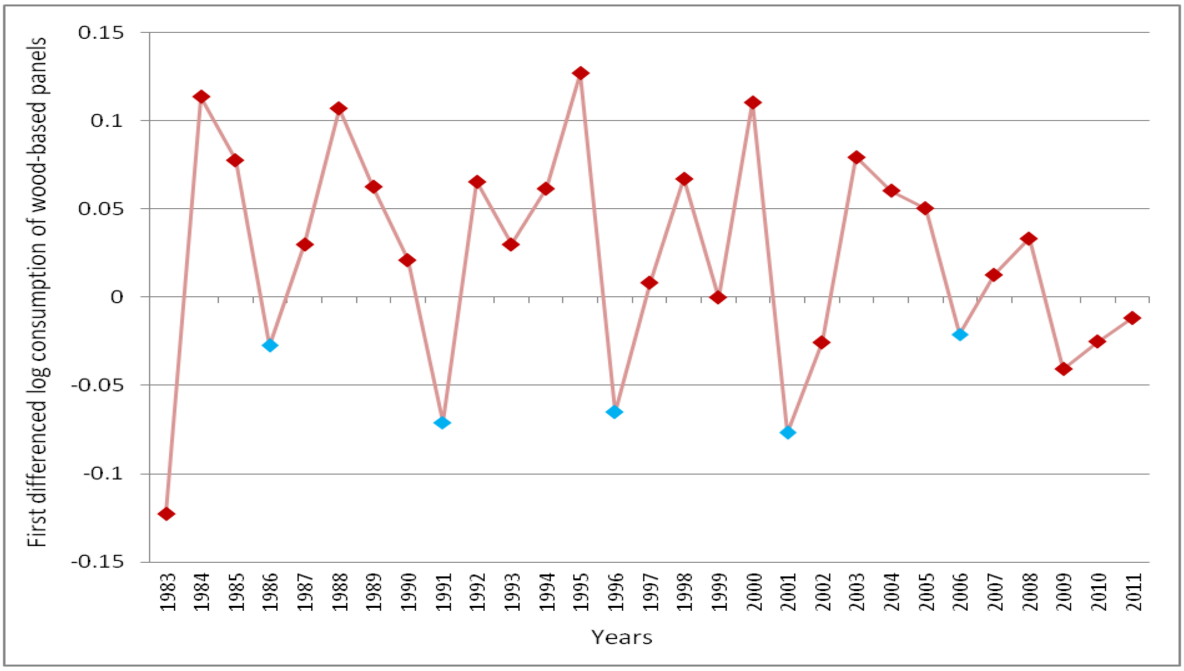
- *ppbc* is total consumption of paper and paperboard (newsprint, printing and writing, packaging and industrial, and household and sanitary paper)
- MANF is the value added by manufacturing sector
- RGDPP is real gross domestic product per capita
- POP is population
- CINC is consumer income
- *ppbi* is total imports of paper and paperboard
- $\text{PRICE}_{\text{WORLD}}$ is the world price of paper and paperboard
- USRGDPP is the United States real gross domestic product per capita.

It was not possible, due to time and data limitations, to estimate and test the relationship between all identified potential factors and paper and paperboard consumption and imports. For example, consumption of newsprint may be affected by substitutes for newspapers, such as electronic media, while consumption of printing and writing paper may be affected by information processing technologies. Consumption of newsprint, household and sanitary and printing and writing paper may also be influenced by changes in consumer income. Similarly, imports of paper and paperboard may be influenced by factors specific to Australia's patterns of trade, which may differ for each paper grade. In addition, the effects of prices of particular paper grades and their substitutes have not been tested. Future analysis could break down consumption and import forecasts into the four major paper grades and incorporate additional potential drivers.

Possible time trend, stationarity and increasing volatility issues were considered and tested using the auto-correlation function (ACF), Partial ACF and Augmented Dickey Fuller (ADF) tests. On completion of these tests it was found that unit root issues were present in all variables requiring us to take the first difference of the data. Further, the log of all variables was taken to enable additional interpretation of coefficients.

A periodic cycle in paper and paperboard consumption was observed in the historic time series, where growth in consumption fell every five years between 1986 and 2006 (Figure A5).

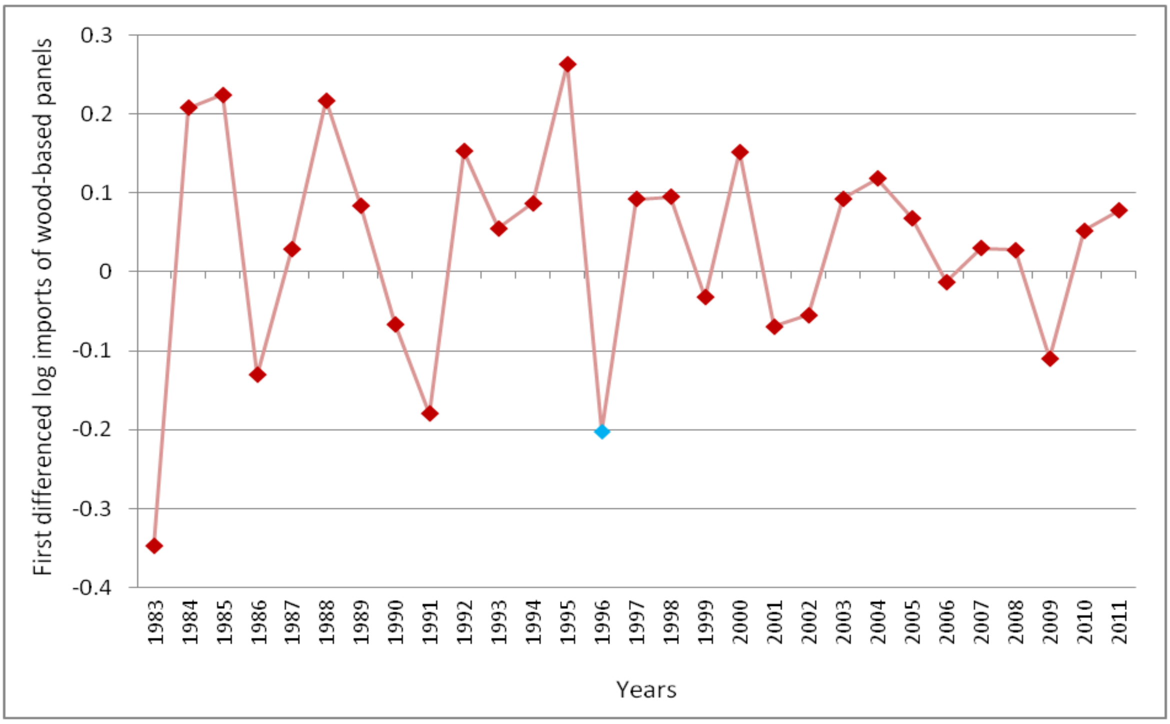
Figure A5 First differenced log consumption of paper and paperboard, 1983–2011



Source: ABARES datasets

There may be an outlier in the quantity of paper and paperboard imports, unexplained by independent variables, in 1996 (Figure A6).

Figure A6 First differenced log imports of paper and paperboard, 1983–2010



Source: ABARES datasets

The consumption and trade econometric forecasting model uses the ordinary least squares (OLS) method. Love and colleagues (1999) and Hossain and colleagues (1989) used a life-cycle model structure to estimate paper and paperboard consumption based on Edquist and Morris (1986). However, this approach requires various assumptions on the current stage of the life cycle of a paper product. It is further difficult to apply to an estimation of imports and thus limited in its forecasting capability and adaptability to a complete scenario-based analysis. Nevertheless, future research and analysis may compare different methodologies, particularly for different grades of paper.

Econometric results

Paper and paperboard consumption

$$\underset{}{\mathrm{d}(\ln(ppb_c))} = \underset{(0.005)}{0.011} + \underset{(0.224)}{0.82\mathrm{d}(\ln(manf))} + \underset{(0.025)}{0.066\mathrm{d92}} + \underset{(0.022)}{0.113\mathrm{d95}} - \underset{(0.016)}{0.067\mathrm{d5busn}}$$

$$+\underset{(3.002)}{12.609\mathrm{d00} \times \mathrm{d}(\ln(manf))} + \underset{(0.145)}{0.305MA(2)} - \underset{(0.156)}{0.356MA(3)} - \underset{(0.14)}{0.634MA(4)} - \underset{(0.156)}{0.315MA(5)}$$

$$R^2_{adj} = 0.833, S.E\ of\ Regression = 0.026$$

Where:

- ppb_c is paper and paperboard consumption in tonnes
- $manf$ is the real value added by manufacturing sector in 2010 Australian dollars
- d92, d95 and d00 are dummy variables for 1992, 1995 and 2000
- d5busn is a five-year business cycle dummy variable between 1986 and 2006
- MA is moving average terms.

This equation was estimated using least squares regression analysis. This method requires all variables used in the modelling to be normally distributed and stationary. To ensure this, the model was constructed on first differenced log data.

The purpose of the model is to establish and test the hypothesised relationship between the value added by the manufacturing sector and paper and paperboard consumption. Hence, specific outliers in consumption and business cycle components were separated to observe the effect of manufacturing output on paper and paperboard consumption.

Dummy variables for outlying consumption levels in 1992 and 1995 were used. A dummy variable was additionally used to account for a specific outlier in the value of manufacturing output in 2000. A periodic cycle in consumption was observed in the historical time series, where growth in consumption fell every five years between 1986 and 2006 (Figure A5). This cyclical component was accounted for using a dummy variable. The moving average terms account for dynamic patterns in consumption between 1983 and 2011 which are assumed to continue to 2050.

The fitted model follows the actual data accurately and within a 95 per cent confidence interval (Figure 10). The model was tested for stability in residuals and forecasts. It appears stable with a high adjusted R-squared value, significant explanatory variables, consistent t-statistics and Durbin–Watson statistic (Table A5). Further testing shows stability in the residuals with no detection of serial correlation or heteroskedasticity. Tests were also undertaken for multicollinearity and co-integration with negative results.

Table A5 Paper and paperboard consumption model: EViews output

Dependent Variable: D(LOG(PPB_C))
Method: Least Squares
Sample: 1983 2011
Included observations: 29
Convergence achieved after 14 iterations
MA Backcast: 1978 1982

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.010676	0.004749	2.248092	0.0366
DLOGMANF	0.820357	0.224055	3.661416	0.0017
D92	0.065558	0.024965	2.625955	0.0166
D95	0.113226	0.021700	5.217896	0.0000
D5BUSN	-0.067374	0.016149	-4.171973	0.0005
D00*DLOGMANF	12.60877	3.002290	4.199718	0.0005
MA(2)	0.305035	0.145199	2.100811	0.0492
MA(3)	-0.355849	0.156119	-2.279342	0.0344
MA(4)	-0.634172	0.139491	-4.546337	0.0002
MA(5)	-0.314807	0.156412	-2.012677	0.0585

R-squared	0.886594	Mean dependent var	0.021784
Adjusted R-squared	0.832876	S.D. dependent var	0.063275
S.E. of regression	0.025867	Akaike info criterion	-4.204865
Sum squared resid	0.012713	Schwarz criterion	-3.733384
Log likelihood	70.97054	Hannan-Quinn criter.	-4.057203
F-statistic	16.50445	Durbin-Watson stat	1.752256
Prob(F-statistic)	0.000000		

Inverted MA Roots	1.00	-.01+.98i	-.01-.98i	-.49+.29i
	-.49-.29i			

The model estimated in EViews suggests a positive coefficient for the value of manufacturing output (explanatory variable). Therefore a positive change in the explanatory variable results in a corresponding positive change in the quantity of paper and paperboard consumption. The coefficients in the model estimate the extent of the change. As these models are constructed in first difference logs, the coefficient approximates a percentage change. Specifically, a 1 per cent increase in the value of manufacturing output results in a 0.82 per cent increase in paper and paperboard consumption.

Paper and paperboard imports

$$\mathrm{d}(\ln(ppb_i)) = 2.27\mathrm{d}(\ln(rgdpp)) - 0.141\mathrm{d}86$$

$$(0.202) \qquad (0.075)$$

$$+ 0.149\mathrm{d}92 - 0.236\mathrm{d}96 - 0.937MA(2)$$

$$(0.061)\ (0.060) \qquad (0.03)$$

$$R_{adj}^2 = 0.763, S.E\ of\ Regression = 0.069$$

Where:

- ppb_i is paper and paperboard imports in tonnes

- $rgdpp$ is real gross domestic product per capita in 2010 AUD
- d86, d92 and d96 are dummy variables for 1986, 1992 and 1996
- $MA(2)$ is a moving average term.

This equation was estimated using least squares regression analysis. This method requires all variables used in the modelling to be normally distributed and stationary. To ensure this, the model was constructed on first differenced log data.

The purpose of the model is to establish and test the hypothesised relationship between paper and paperboard imports and GDP per capita. Hence, specific outliers in imports were separated to observe the effect of real GDP per capita on paper and paperboard imports. Dummy variables for outlying import quantities in 1986, 1992 and 1996 were used. The moving average term accounts for dynamic patterns in imports between 1983 and 2010 which are assumed to continue to 2050.

The fitted model follows the actual data accurately and within a 95 per cent confidence interval (Figure 12). The model was tested for stability in residuals and forecasts. It appears stable with a high adjusted R-squared value, significant explanatory variables, consistent t-statistics and Durbin–Watson statistic (Table A6). Further testing shows stability in the residuals with no detection of serial correlation or heteroskedasticity. Tests were also undertaken for multicollinearity and co-integration with negative results.

The model estimated in EViews suggests a positive coefficient for real GDP per capita. Therefore a positive change in the explanatory variables results in a corresponding positive change in the quantity of paper and paperboard imports. The coefficients in the model estimate the extent of the change. As these models are constructed in first difference logs, the coefficient approximates a percentage change. Specifically, a 1 per cent increase in real GDP results in a 2.3 per cent increase in paper and paperboard imports.

Table A6 Paper and paperboard imports model: EViews output

Dependent Variable: D(LOG(PPBI))
Method: Least Squares
Sample: 1983 2010
Included observations: 28
Convergence achieved after 14 iterations
MA Backcast: 1981 1982

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(RGDPP))	2.270230	0.202336	11.22009	0.0000
D86	-0.141295	0.075060	-1.882429	0.0725
D92	0.148843	0.061284	2.428753	0.0234
D96	-0.235843	0.059581	-3.958366	0.0006
MA(2)	-0.937118	0.029944	-31.29588	0.0000

R-squared	0.797876	Mean dependent var	0.030261
Adjusted R-squared	0.762724	S.D. dependent var	0.140843
S.E. of regression	0.068606	Akaike info criterion	-2.360437
Sum squared resid	0.108256	Schwarz criterion	-2.122543
Log likelihood	38.04611	Hannan-Quinn criter.	-2.287710
Durbin-Watson stat	1.807879		

Inverted MA Roots	.97	-.97

Appendix B: Data assumptions

In developing forecasts, the relationships between variables established through econometric analysis of historical data are expected to continue into the future. In reality, the reliability of forecasts will likely diminish as they extend further into the future, given the reduced reliability of forecasts of underlying variables. This may arise because of changing relationships between these variables, such as changes to the type of housing construction over time or growth in GDP. This appendix lists the assumptions used to project the underlying variables used in the econometric analysis of wood product consumption and trade.

Household size

Household size historical data were sourced from ABS social trends data. A linear trend was fit to project household sizes which are estimated to decrease to 2.38 in 2029–30 and 2.24 in 2049–50.

Population

Population historical data were sourced from ABS census data and forecast to 2049–50 using the growth path assumed in *Strong Growth, Low Pollution* (Australian Government 2011). Population is forecast to be 29 036 783 in 2029–30 and 35 743 718 in 2049–50.

While this report uses population projections based on Australian Government (2011) assumptions, population projections in the recently released *Food demand to 2050* (Linehan et al. 2012) ABARES report were based on the median variant of UN population projections in 2010. As the *Food demand to 2050* report had a different, more global focus, UN projections were chosen in that report for consistency when comparing modelling results with other countries.

Total dwellings

Forecasts for total dwelling commencements rely on household size, population size and a derived estimate for total households. The number of detached and multi-dwelling commencements was derived based on the forecast for total dwelling commencements.

We first determine the number of total households:

$$Total\ Households\ (TH_t) = \frac{Population_t}{Household\ Size_t}$$

Where:

- t represents time.

Total dwellings commenced was forecast using the following equation:

$$TD_t = (\mathrm{TH_t} - \mathrm{TH_{t-1}}) + \boldsymbol{a} \times \mathrm{TH_{t-1}}$$

Where:

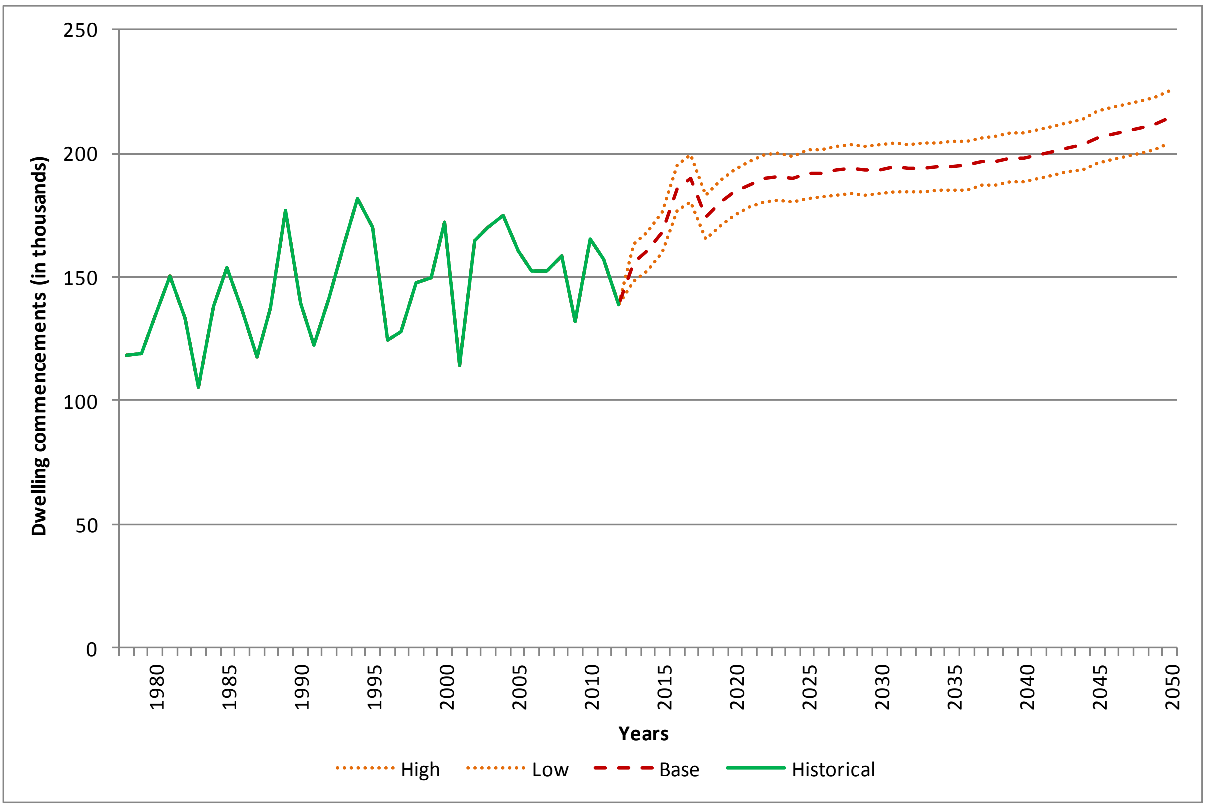
- TD_t represents the total number of dwelling commencements at time t
- $\mathrm{TH_t}$ represents the derived total number of households at time t
- $\mathrm{TH_{t-1}}$ represents the derived total number of households at time $t-1$
- $'\boldsymbol{a}'$ represents a factor to account for replacement of existing housing stock.

Historically, $'\boldsymbol{a}'$ was calculated by re-arranging the above equation. It was then projected to 2049–50 using a six-year moving average.

The resulting forecasts for total dwellings commenced were 193 619 in 2029–30 and 214 670 in 2049–50 (Figure B1). Decreasing household sizes and an increase in population up to 2050 are expected to increase demand for new dwellings—particularly multi-dwellings in Australia.

The 'high' and 'low' estimates for dwelling commencements are based on a +/- 5 per cent deviation from the baseline projection for total dwellings. Comparing the forecasts for total dwelling commencements from Love and colleagues (1999) with actual historical data for the last decade shows an average positive error of around 4.8 per cent and an average negative error of around 4.4 per cent. A 5 per cent deviation was thus chosen by examining these error margins to acknowledge the potential errors and uncertainty associated with ABARES projections for total dwelling commencements.

Figure B1 Number of total dwelling commencements, actual 1978–2011, forecasts 2012–50



Source: ABARES projections, HIA datasets

Multi-dwellings and detached dwellings

Multi-dwelling and detached dwelling commencements were estimated as proportions of total dwelling commencements. The 'high' and 'low' estimates are also based on the same margin for error in ABARES projections as discussed in the assumptions for total dwellings.

Detached dwelling commencements were used for the econometric model estimating sawnwood consumption while multi-dwellings was used in the models estimating sawnwood consumption and imports and wood-based panel consumption and imports.

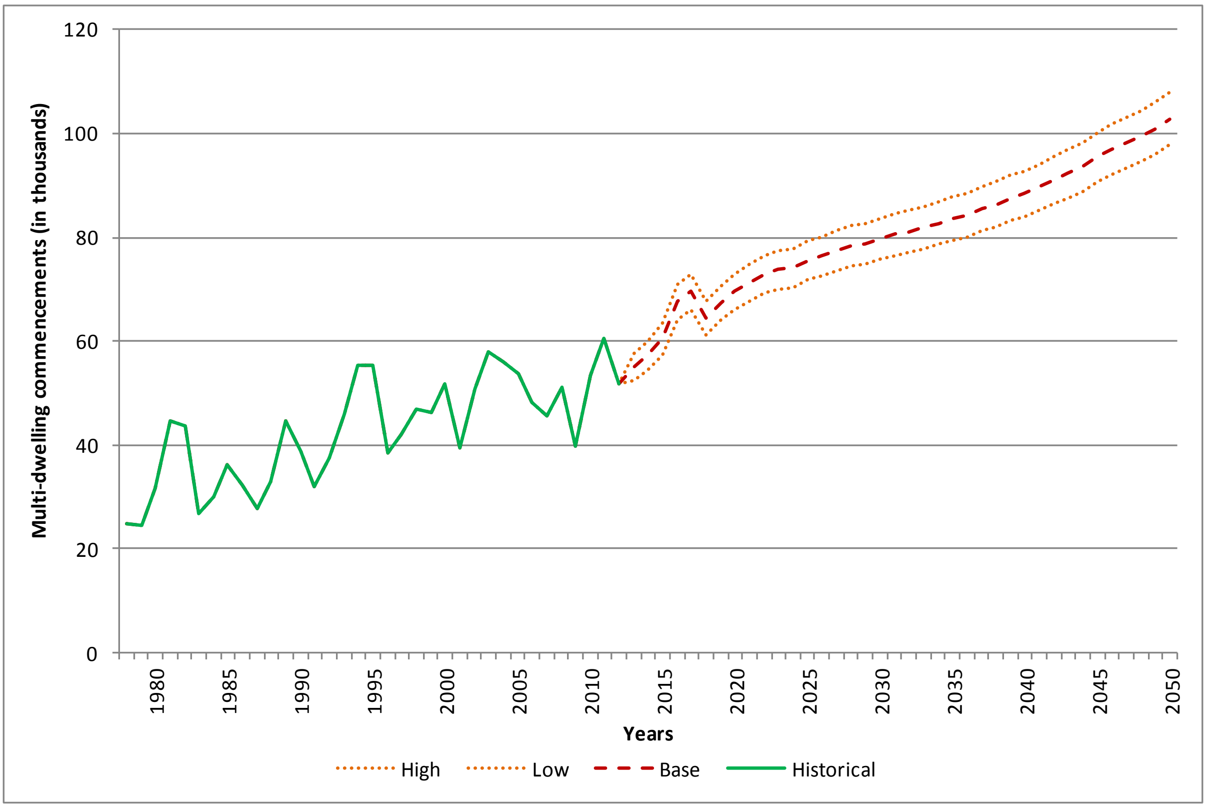
Infrastructure Australia (2010) estimated that 72 per cent of population growth occurring to 2050 will occur in capital cities. Based on this information and historical trends observed in HIA housing data (HIA Economics 2012), the proportions of multi and detached dwellings to total dwellings between 2011–12 and 2049–50 were estimated using a logarithmic trend. These proportions were applied to total dwellings to derive multi and detached dwelling commencements. In 2029–30 multi-dwelling and detached dwelling commencements are forecast to be 79 620 and 113 999, respectively, and 102 875 and 111 795, respectively, in 2049–50 (Figure B2).

Detached and multi-dwelling commencements are forecast to rise based on the increase required in total dwellings to meet growing population and decreasing household sizes in Australia. While the growth in detached dwelling commencements is a marginal increase, given the concentration of population growth in capital cities, multi-dwellings are forecast to grow at a faster rate than detached dwellings.

Figure B2 Number of detached dwelling commencements, actual 1978–2011, forecasts 2012–50

Source: ABARES projections, HIA datasets

Figure B3 Number of multi-dwelling commencements, actual 1978–2011, forecasts 2012–50

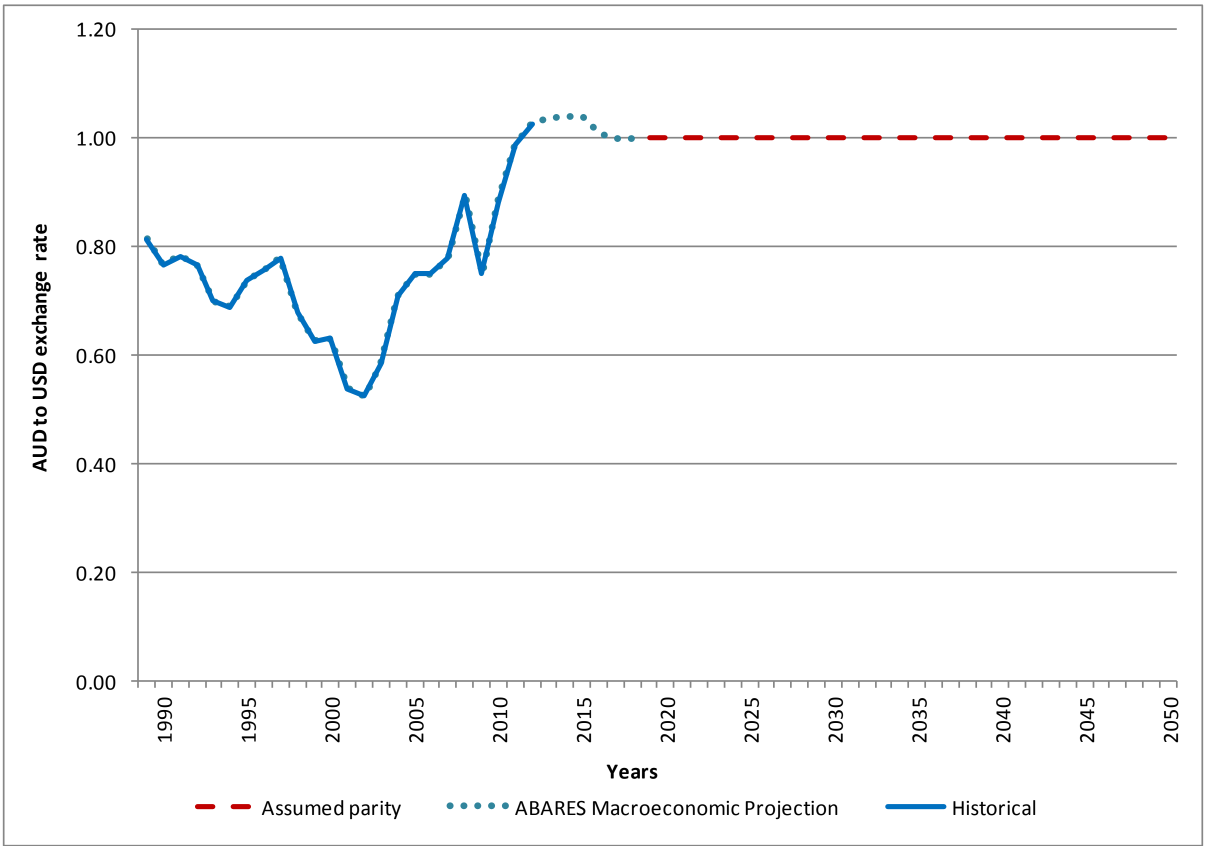


Source: ABARES projections, HIA datasets

Australian to US dollar exchange rate

The Australian to US dollar exchange rate was used in the econometric model estimating sawnwood imports. Exchange rates are considered volatile and are affected by a range of macroeconomic indicators in Australia and in other economies. It is difficult to predict movements in this variable. Therefore the Australian to US dollar exchange rate was projected to 2017–18 based on available information (ABARES Macroeconomic assumptions). Based on the trend to 2017–18, the Australian to US dollar exchange rate is assumed to remain stable at parity thereafter (Figure B4).

Figure B4 Australian to US dollar exchange rate, actual 1989–2011, forecasts 2012–50



Source: ABARES projections

Value of approved alterations and additions (renovations)

The model for wood-based panel consumption relies on forecasts for the value of approved alterations and additions which use household size, population and a historical proportion of renovations on existing houses.

$$\textit{Proportion of renovations on existing houses} = \frac{\textit{Value of approved alterations and additions}}{\textit{Total households}}$$

The historical value of approved alterations and additions was sourced from the ABS and converted to real 2004 dollars using a housing consumer price index, also sourced from the ABS.

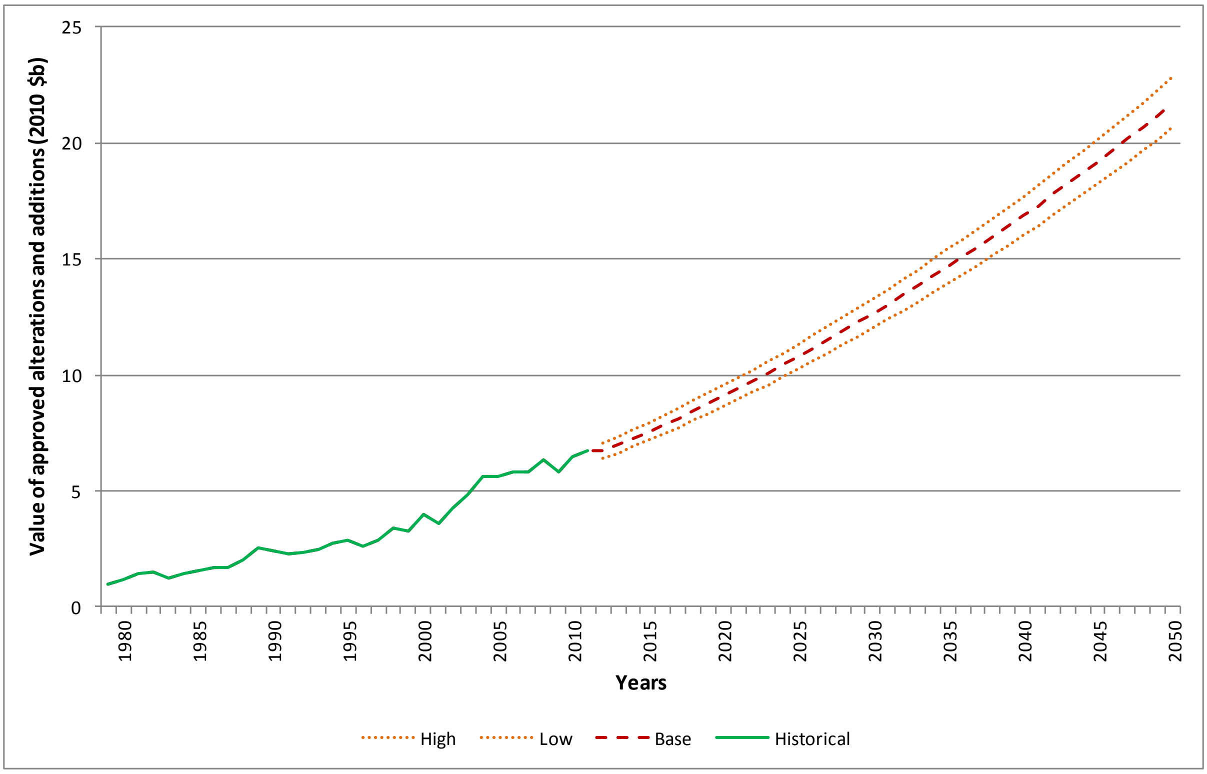
The number of total households was derived as

$$Total\ Households\ (TH_t) = \frac{Population_t}{Household\ Size_t}$$

The proportion of renovations on existing houses was forecast to 2050 using a logarithmic trend. By multiplying this proportion with the derived number of total households, the value of approved additions and alterations was estimated. The real value of approved alterations and additions (in 2010 Australian dollars) is forecast to be $12.6 billion in 2029–30 and $21.7 billion in 2049–50 (Figure B5).

Given an increase in the number of dwellings to 2050, the real value of approved alterations and additions is also expected to rise. A 'high' and 'low' estimate is also considered in the form of a 5 per cent error margin to acknowledge the uncertainty associated with the ABARES projection.

Figure B5 Value of approved alterations and additions, actual 1983–2011, forecasts 2012–50

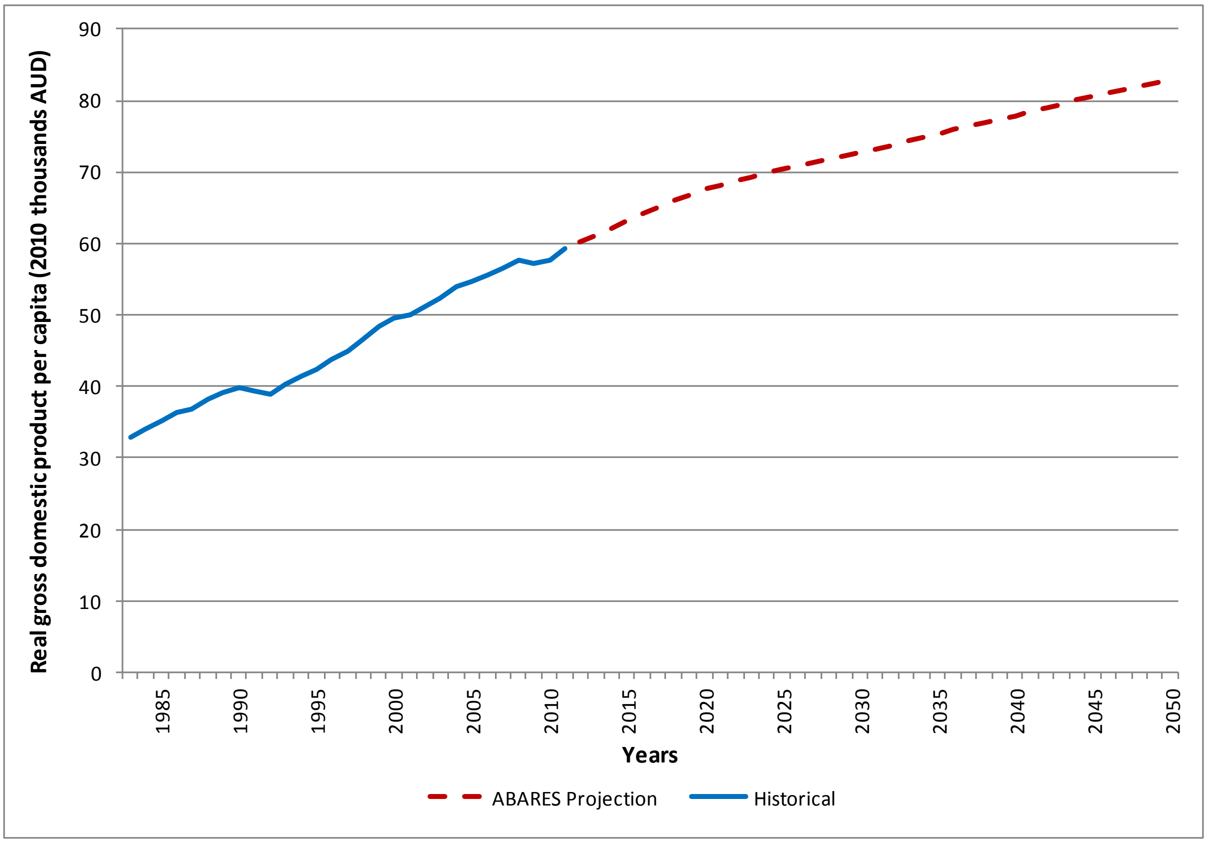


Source: ABARES projections, ABS datasets

Real gross domestic product per capita

ABS historical data was used from 1974–75 to 2009–10. Real gross domestic product was then forecast using the growth path outlined by Global Trade and Environment Model (GTEM) projections. GTEM is a CGE model ABARE developed to address policy issues with global dimensions, such as international trade and is useful in projecting various macroeconomic indicators. See Pant (2007) for a detailed description of the theoretical structure of GTEM. A per capita estimate was derived by dividing real gross domestic product in each year with the corresponding population forecast for that year.

Figure B6 Real gross domestic product per capita (2010 Australian dollars), actual 1983–2010, forecasts 2011–50

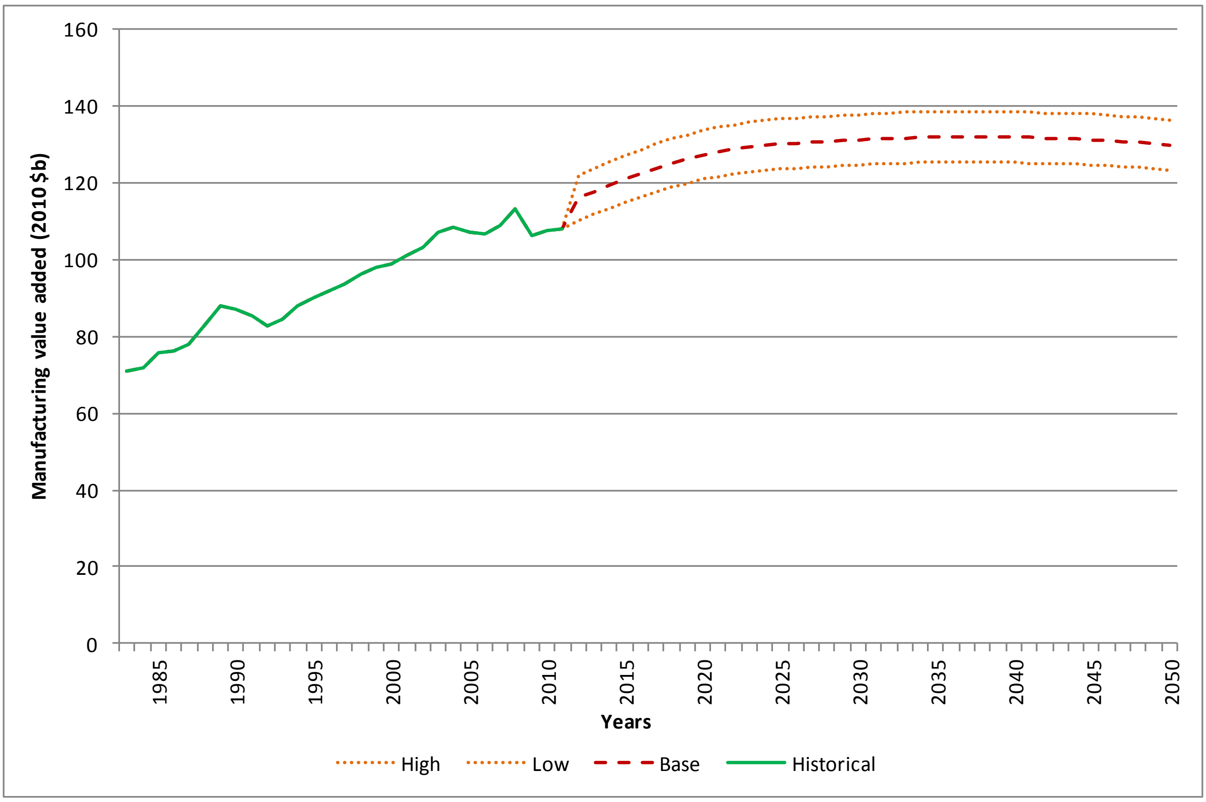


Source: ABS datasets, ABARES projections

Value of manufacturing output

The proportion of value added by the manufacturing sector to real GDP was estimated historically between 1974–75 and 2009–10. An exponential trend was then fit to estimate these proportions out to 2049–50. This trend assumes the contribution of the manufacturing sector to Australia's GDP is gradually declining over time from around 8 per cent in 2009–10 to around 4 per cent in 2049–50. Manufacturing value added was then derived by applying these proportions to the forecast for real GDP. The value added by the manufacturing sector is estimated to increase out to 2029–30 before levelling off and declining marginally thereafter (Figure B7).

Figure B7 Value of manufacturing output, actual 1983–2011, forecasts 2012–50



Source: ABS datasets, ABARES projections

Estimating the volume of pulplogs used domestically

Conversion factors were used to convert the volume of domestic production of paper and panels to pulplog equivalents (Table B1). This provides an indication of the volume of pulplogs used domestically. For pulplog harvest, calendar year data was assumed to be interchangeable with financial year data in this report.

The volume of pulplogs harvested for domestic production of paper and panels was divided by the volume of production of paper and panels in each year between 1997 and 2011. The conversion factor for total paper was calculated by averaging these ratios over the 15-year period. There appears to be a significant difference in the ratio for panels between 1997–2003 and 2004–11. Hence, the panel conversion factor was based on the average ratio between 2004 and 2011.

Similarly the volume of pulplogs harvested for woodchip exports was divided by the volume of woodchip exports. The conversion factor for woodchip exports was calculated by averaging these ratios over the 15-year period between 1997 and 2011.

Table B1 Conversion factors for wood products to pulplog equivalents

Type	Units	Conversion factor product to pulplog equivalent m³
Total paper **a**	'000 tonnes	1.02
Particleboard and MDF **b**	m³	0.75
Woodchips	m³	1.79

a Includes newsprint, printing and writing, household and sanitary, and packaging and industrial paper; **b** MDF = medium density fibreboard.

Source: ABARES datasets

Estimating the volume of pulplogs actually harvested

Gavran and colleagues (2012) and ABARES (2012) have previously estimated the potential volume of pulplogs available for harvest. The forecasts are based on the assumption that harvested areas will be replanted with the same type of plantation species. The forecasts do not take into account any future management decisions such as plantations with low growth rates not being replanted and converted to another land use. ABARES updated these forecasts based on anecdotal information from industry and stakeholders. As further information becomes available, the forecasts may be revised to reflect these changes. These estimations were for calendar year data and are assumed to be interchangeable with financial year data in this report. To forecast the volume of woodchip exports, conversion factors were used to estimate the actual volume of pulplogs harvested.

Parsons and colleagues (2007) and Ferguson and colleagues (2002) have previously estimated the annual average pulplog availability from plantations in 2001–04 and 2005–09. ABARES assumed this average annual availability to represent availability in the middle of each five-year period. A linear trend was then used to interpolate the availability in intervening years between each midpoint. A simple ratio of potential to actual harvest was then calculated. The conversion factor for pulplogs harvested from hardwood and softwood plantations was calculated by averaging these ratios over the past decade (Table B2).

Based on data from ABARES datasets, a similar ratio of availability to actual harvest was calculated for pulplog harvest from native forests.

Table B2 Conversion factors for availability to actual pulplog harvest

Type	Conversion factor
Native pulplog harvest	0.95
Hardwood plantation pulplog harvest	0.68
Softwood plantation pulplog harvest	0.90

Source: ABARES datasets

Appendix C: Reduced form analysis

This appendix briefly outlines reduced form analysis that incorporates the definition of apparent consumption and determines imports based on the historical and forecast level of consumption. Future research and analysis may test this methodology in greater detail when using FORUM to model production and investment decisions.

Consider the following system of equations:

$$Cons_t = Prod_t + Imp_t - Exp_t \qquad ..... (1)$$

$$Imp_t = \beta_1 Cons_t + \beta_2 R_t \qquad ..... (2)$$

Equation (1) is an identity equation based on the definition of apparent consumption. Equation (2) is a model for imports based on consumption and some independent macroeconomic variable '*R*'.

In this system of equations, endogenous variables are:

$Cons_t = Consumption\ at\ time\ t$

$Imp_t = Imports\ at\ time\ t$

In this system of equations, exogenous variables are:

$Prod_t = Production\ at\ time\ t$

$Exp_t = Exports\ at\ time\ t$

$R_t = some\ explanatory\ variable\ influencing\ imports\ at\ time\ t$

Production and exports are treated as exogenous as these are forecast using FORUM and used as inputs to this system of equations.

Putting (1) in (2):

$$Imp_t = \beta_1 (Prod_t + Imp_t - Exp_t) + \beta_2 R_t$$

$$Imp_t - \beta_1 Imp_t = \beta_1 (Prod_t - Exp_t) + \beta_2 R_t$$

$$(1 - \beta_1) Imp_t = \beta_1 (Prod_t - Exp_t) + \beta_2 R_t$$

$$Imp_t = \frac{\beta_1}{(1-\beta_1)} (Prod_t - Exp_t) + \frac{\beta_2}{(1-\beta_1)} R_t \qquad ..... (3)$$

Putting (3) in (1):

$$Cons_t = Prod_t + \frac{\beta_1}{(1-\beta_1)} (Prod_t - Exp_t) + \frac{\beta_2}{(1-\beta_1)} R_t - Exp_t$$

Rearranging,

$$Cons_t = \frac{1}{(1-\beta_1)} (Prod_t - Exp_t) + \frac{\beta_2}{(1-\beta_1)} R_t \qquad ..... (4)$$

In this methodology, we would model equations (3) and (4) and could use the resulting coefficients to derive estimates for consumption and imports based on equations (1) and (2).

References

ABARES 2012, *Potential effects of climate change on forests and forestry in Australia*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Australian Government 2011, *Strong Growth, Low Pollution: modelling a carbon price*, The Treasury, Canberra, archive.treasury.gov.au/carbonpricemodelling/content/chartsandtables.asp, accessed 23 May 2012.

Burke, B & Townsend, P 2011, 'Sawnwood', *Agricultural Commodities: September quarter 2011*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, pp.108–113.

de Fégely, R, Blyth, M & Burns, K 2006, *Scenarios for selected timber markets: summary report*, report to the Forest and Wood Products Research and Development Corporation, project no. PN05.1021.

Edquist, A & Morris, P 1986, 'Long term projections of the consumption of paper and paper products in Australia', *Review of Marketing and Agricultural Economics*, vol. 53, pp. 157–71.

Ferguson, I, Fox, J, Baker, T, Stackpole, D & Wild, I 2002, *Plantations of Australia – Wood Availability 2001–2044,* consultant's report for the National Forest Inventory, Bureau of Rural Sciences, Canberra.

Gavran, M, Frakes, I, Davey, S & Mahendrarajah, S 2012, *Australia's plantation log supply 2010–2054*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, adl.brs.gov.au/data/warehouse/afplsd9abfe001/afplsd9abfe00120120515/AustLogSupply2012_2054_v.1.0.0.pdf (pdf 5.17 mb).

HIA Economics 2012, accessed May 2012, economics.hia.com.au/media/July%202012%20%20Forecasts.pdf (pdf 173 kb).

Hossain, M, Sar, L, & Samuel, N 1989, *Long term consumption projections for forest products*, ABARE Discussion Paper 89.6, Australian Bureau of Agricultural and Resource Economics, Canberra, adl.brs.gov.au/data/warehouse/pe_abarebrs99000187/pc10112.pdf (pdf 2.44 mb).

Infrastructure Australia 2010, *State of Australian Cities 2010*, Canberra, March, infrastructure.gov.au/infrastructure/mcu/soac_files/MCU_SOAC.pdf (pdf 9.90 mb), accessed 6 June 2012

Linehan, V, Thorpe, S, Andrews, N, Kim, Y & Beaini, F 2012, *Food demand to 2050: Opportunities for Australian agriculture*, ABARES conference Canberra, March.

Love, G, Yainshet, A & Grist, P 1999, *Forest products: long term consumption projections for Australia*, ABARE research report 99.5, Australian Bureau of Agricultural and Resource Economics, Canberra, adl.brs.gov.au/data/warehouse/pe_abarebrs99000433/PC11465.pdf (pdf 372.76 kb).

Majumdar, S, Zhang, D & Zhang, Y 2010, 'Estimating regional softwood lumber supply in the United States using seemingly unrelated regression', *Forest Products Journal*, vol. 60, no. 7/8, pp. 709–14, fp.auburn.edu/sfws/zhang/RefereedPub/FPJ2010–11.pdf (pdf 334.8 kb).

Parsons, M, Frakes, I & Gavran, M 2007, *Australia's Plantation Log Supply 2005–2049*, Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry, Canberra, adl.brs.gov.au/data/warehouse/pe_brs90000003693/logSupply.pdf (pdf 2.75 mb).

Pant, H 2007, *GTEM: Global Trade and Environment Model*, ABARE Technical Report. ABARE, Canberra.

Townsend, P 2010, 'Woodchips', *Agricultural Commodities: September quarter 2010*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, pp. 524–29.