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Responsiveness of demand for structural pine to changes in timber and steel prices

A study using the FWPA softwood data series

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Summary

This report was jointly funded by Forest and Wood Products Australia (FWPA) and ABARES to estimate the responsiveness of demand for structural pine to changes in timber and steel prices. Measures of demand responsiveness can provide valuable insights into the potential implications of changes in policy or market settings on volumes and prices received by producers. The analysis focuses on estimating short-term price elasticities of demand—a formal measure of the sensitivity of demand—to changes in prices in the same quarter or recent past.

For this report ABARES estimated price elasticities of demand for domestically produced structural pine (FWPA softwood data series) with respect to the domestic price of MGP10 (machine graded pine), imported structural pine prices, and prices for steel beams and sections used in housing construction.

ABARES tested a large number of models with varying functional forms and combinations of variables to estimate price elasticities of demand. The estimated models of demand are based on historical relationships between the FWPA softwood sales data series and various explanatory variables. The estimates outlined in this report should also be considered in the context of the assumptions and limitations of the data used in ABARES modelling. In particular, the models of demand developed by ABARES are considered to be a proxy for national demand, as they only cover producers who are included in the FWPA survey.

The estimates presented in this report are based on industry-level demand and average prices. As such, they are not applicable to changes in demand or prices of individual producers. Changes in prices of individual producers will likely lead to much larger changes in demand for their products, but little to no change in industry-level demand.

The estimates suggest timber and steel prices are not major determinants of demand for domestically produced structural pine products in the short term, with non-price factors playing a more important role. The report presents insights into these non-price factors—such as house commencements, environmental concerns, consumer preferences and building code changes—as alternative determinants of demand. The findings presented in this report are broadly consistent with previous estimates of price elasticities of demand for structural timber in Australia and internationally.

Key findings

Timber and steel prices

Changes in the domestic price of structural pine (MGP10) have a relatively small impact on demand for domestically produced structural pine (Table S1). A 1 per cent increase in MGP10 prices was estimated to reduce demand for domestically produced untreated structural pine by between 0.06 and 1.28 per cent, reduce demand for treated structural pine by between 0.54 and 0.82 per cent and reduce demand for the aggregate of the two by between 0.08 and 0.55 per cent. However, a number of these estimates were not statistically different from zero at the 95 per cent confidence level, suggesting potentially no effect on demand for structural pine. There was evidence that changes in domestic prices were more likely to have a delayed, rather than immediate, impact on demand—with changes in prices in the previous quarters having a statistically significant effect on demand.

Changes in import prices for structural pine products had a small effect on demand for domestically produced structural pine. A 1 per cent increase in imported structural pine prices was estimated to increase demand for domestically produced untreated structural pine by up to 0.14 per cent, increase demand for domestically produced treated structural pine by up to 0.18 per cent, and increase demand for the aggregate of the two by up to 0.20 per cent. These estimates were statistically insignificant at the 95 per cent confidence level, which implies that import prices may have little effect on demand for domestically produced structural pine in the short-term.

Table S1 Change in demand for domestically produced structural pine in response to 1 per cent change in timber and steel prices

Price variables	Untreated structural pine (%)	Treated structural pine (%)	Aggregate structural pine (%)	Domestic share (%)
Domestic MGP10 price	–1.28 to –0.06 **b**	–0.82 to –0.54 **b**	–0.55 to –0.08 **b**	–0.42 to –0.21 **b**
Imported structural pine prices	–0.13 to 0.14	–0.03 to 0.18	–0.01 to 0.20	–0.06 to 0.30 **b**
Price of steel beams and sections used in housing—whole period	–0.36 to –0.09	–0.54 to 0.18 **b**	–0.35 to 0.15	0.08
Price of steel beams and sections used in housing—before September quarter, 2007	1.27 **a**	–	0.99 **a**	–
Price of steel beams and sections used in housing—during and after September quarter, 2007	–0.16	–	–0.44	–

a Estimate statistically significant at the 95 per cent confidence level. **b** Some estimates in this range were statistically significant at the 95 per cent confidence level.
Note: There was no evidence of a structural break with respect to steel prices for models of treated structural pine or the domestic market share.

However, there is evidence that changes in import prices may have an impact on the share of domestic demand met by domestic production. For example, a 1 per cent increase in import prices was estimated to increase the market share of domestically produced structural pine by up to 0.30 per cent, with a number of the estimates being statistically significant. These results are consistent with changes in import prices affecting demand for imports to a greater degree than demand for domestically produced structural pine.

The price of steel beams and sections used in housing construction was estimated to have a negative effect on demand for domestically produced structural pine over the sample period. That is, increases in steel prices reduced demand for domestically produced structural pine. This finding is inconsistent with steel and timber being price substitutes. However, when the responsiveness of demand to steel prices was allowed to change over the sample period, the results indicated strong and statistically significant price substitution between steel and domestically produced structural pine before the September quarter of 2007, or the beginning of the global financial crisis (GFC). During and after the GFC, however, steel prices appeared to have little effect on demand for domestically produced structural pine.

It should be noted, however, that the ABS price index for steel beams and sections used in housing is an aggregate of multiple steel products, some of which may not be directly substitutable with structural pine. This could, in part, explain why some of the model results indicate a limited effect of steel prices on demand for domestically produced structural pine after the September quarter of 2007.

Overall, ABARES estimates suggest a weak relationship between timber and steel prices and demand for domestically produced structural pine—many of the estimated coefficients are statistically insignificant.

Non-price factors

Changes in the number of house commencements and, to a lesser degree, the value of work done on new houses have a more substantial impact than prices on demand for domestically produced structural pine (Table S2). A 1 per cent increase in new house commencements was estimated to increase demand for domestically produced untreated pine by up to 0.64 per cent, demand for domestically produced treated pine by up to 0.99 per cent, and demand for the aggregate of the two by up to 0.69 per cent. The effect of house commencements on structural timber demand was found to be statistically significant in all models considered but the effects of the value of work done was mixed.

Table S2 Change in demand for domestically produced structural pine in response to 1 per cent change in residential housing activity

Variables	Untreated structural pine (%)	Treated structural pine (%)	Aggregate pine (%)
House commencements **a**	0.36 to 0.64	0.77 to 0.99	0.48 to 0.69
Value of work done on new houses	0.14 to 0.31	0.00 to 0.33	0.26 to 0.44 **b**

a All estimates were statistically significant at the 95 per cent confidence level. **b** Some estimates in this range were statistically significant at the 95 per cent confidence level.

Other non-price factors may also explain why changes in the relative prices of timber and steel are not necessarily matched by a corresponding change in consumption. For example, differences in order lead times between materials can offset any cost savings associated with lower material prices. Long order lead times impose costs on builders—including idling capacity, having to turn down potential projects and difficulty planning for the future. Offsite prefabrication (of timber frames, for example) can reduce build times and onsite flexibility can minimise delays. These have implications for build times and labour costs that aren't accounted for in material prices alone. When these additional factors are taken into account, a large price differential may be required before substitution between materials occurs.

Changing consumer preferences has also had an effect on the choice of construction material. Consumers are increasingly opting for open plan houses, which require fewer internal walls, decreasing the required amount of material inputs. However, this means structural construction systems need to be stronger, placing a greater emphasis on strength and durability of the material used. With environmental issues becoming increasingly important, consumers may place more weight on the environmental properties of various construction systems and materials. Recent changes to the National Construction Code could allow for increased timber use in the midrise construction market, leading to potentially higher timber use in multi-storey buildings in the future.

Introduction

This report was jointly funded by Forest and Wood Products Australia (FWPA) and ABARES to estimate the responsiveness of demand for structural pine to changes in building material prices. Measures of demand responsiveness can provide valuable insights into the potential implications of changes in policy or market settings on volumes and prices received by producers.

Price elasticity of demand is used as a formal measure of the responsiveness of demand to changes in prices. Price elasticities of demand measure the hypothetical change in demand for a good or service in response to a change in its own-price or the prices of other goods, holding all else constant. The literature on price elasticities of demand is extensive but recent estimates for structural timber markets, especially in Australia, are scarce. This report presents estimates of the responsiveness of demand for untreated, treated and aggregate structural pine to changes in prices, using econometric models of quarterly demand for selected structural timber products. Demand for structural pine products is derived from monthly sales volume data collected by FWPA from a proportion of major softwood sawnwood producers in Australia and is considered a proxy for national demand. Price elasticities of demand are estimated with respect to the domestic price of structural timber, the price of imported softwood sawnwood products and the price of steel beams and sections used in housing construction.

In developing the models of demand used to estimate price elasticities, ABARES tested a large number of models with varying functional forms and combinations of explanatory variables. The estimated models of demand are based on historical relationships between the FWPA softwood sawnwood sales data series and various explanatory variables.

The estimates presented in this report are based on industry-level demand and average prices. As such, they are not applicable to changes in demand or prices of individual producers. Changes in prices of individual producers will likely lead to much larger changes in demand for their products. The analysis focuses on estimating short-term price elasticities of demand—a formal measure of the sensitivity of demand—to changes in prices in the same quarter or recent past.

The estimates should also be considered in the context of the assumptions and limitations of the data used in ABARES modelling. In particular, the models of demand developed by ABARES are considered to be a proxy for national demand, as they only cover producers who are included in the FWPA survey.

The remainder of this report is set out as follow. Chapter 1 provides a brief background on 'price elasticities of demand' as a measure of demand responsiveness and discusses the key datasets used. Chapter 2 presents estimates of price elasticities of demand with respect to timber and steel prices and Chapter 3 discusses non-price factors which play an important role in determining demand for domestically produced structural pine. The report concludes with a brief discussion of key results and implications. Appendix A discusses the technical aspects of model development while Appendix B presents detailed model outputs.

1 Background

1.1 Price elasticities of demand

Price elasticities of demand are formal measures of how responsive demand for a good or service is to a change in its own-price, or prices of competitive goods. Price elasticities of demand are unit-free measures and represent the percentage change in demand in response to a hypothetical 1 per cent increase in price, holding all other factors constant (Equation 1).

Equation 1 Price elasticity of demand

$$Elasticity\ of\ demand = \frac{\%\ change\ in\ demand}{\%\ change\ in\ price}$$

Own-price elasticities of timber measure the responsiveness of timber demand to changes in the price of timber. This can be interpreted as hypothetical movements along the demand curve for timber. Own-price elasticities are typically negative, meaning an increase in price usually leads to a decrease in the quantity demanded.

In contrast, cross-price elasticities of timber measure the responsiveness of timber demand to changes in prices of other products such as steel. These can be interpreted as hypothetical shifts in the demand curve for timber. Cross-price elasticities may be positive if the goods are substitutes or negative if the goods are complements.

Elasticities of demand range between two extremes. Demand for a good or service is considered perfectly elastic', with respect to a change in price if an increase in price reduces demand for the product to zero. Conversely, demand for a good is considered perfectly inelastic if the quantity demand is unaffected by changes in prices. In practice, price elasticity estimates fall somewhere between these two extremes. Demand for a good or service is typically referred to as elastic', with respect to a particular price if the percentage change in demand is greater than the percentage change in price. That is, the price elasticity of demand is greater than one in absolute terms. In contrast, if a percentage change in demand is smaller than a percentage change in price, demand for the good is referred to as inelastic—that is, the price elasticity of demand is less than one in absolute terms.

Numerous factors influence price elasticities of demand, including the necessity of a product as an input, the proportion of total expenditure spent on the product and the availability of substitutes. For example, demand for a product is less responsive to changes in its own-price where the product is an important input to production, makes up a small share of total expenditure, and has few available substitutes.

1.1.1 Price elasticities of demand estimated in this report

The price elasticities of demand presented in this report are measures of the responsiveness of demand to changes in average prices at the industry level. These differ from demand responsiveness for an individual buyer (for example, an individual builder), which will depend on that user's specific production methods, costs, outputs and preferences. They also differ from demand responsiveness for a particular producer's product with respect to the price charged by that producer. Demand for a single seller's products tends to be highly responsive to the price charged by that seller due to competition between producers within the industry. For example, a single supplier lowering their prices (relative to their competitors) could significantly increase their market share but have minimal effect on overall timber demand.

This report focuses on estimating short-term price elasticities of demand, or the sensitivity of demand, to changes in prices in the same quarter or recent past. In contrast, long-term elasticities measure the sensitivity of demand to permanent changes in prices in the long-run steady state. Long-run elasticities are typically larger in magnitude than short-run elasticities as users have more substitution possibilities. For example, in the short-run users are restricted by long-term contracts and production schedules (Gaston 1979), which require decision-making in advance and cannot be changed in the short-term.

1.2 Datasets

The datasets and sources included in the final models presented in this report are summarised in Table 1. Three categories of demand were considered: 1) demand for untreated structural pine; 2) demand for treated structural pine; and 3) demand for the aggregate of untreated and treated structural pine.

Table 1 Data sources

Variable	Source
Structural pine sales	
Sales of untreated structural pine framing	FWPA 2018
Sales of treated structural pine framing	FWPA 2018
Material prices	
Domestic price index for MGP10	Indufor 2017
Domestic price index for steel beams and sections used in housing	ABS 2017c
Import price of dressed softwood sawnwood (comprises untreated, treated and other categories)	ABS 2017b
Residential construction activity	
House commencements	ABS 2017a
Other commencements	ABS 2017a
Value of work done on new houses	ABS 2017a

MGP Machine graded pine.
Note: Variables reported at the monthly frequency were aggregated up to a quarterly frequency.

1.2.1 Demand for structural pine

Quarterly sales of structural pine were aggregated up from monthly sales data reported by FWPA (2018). In using the FWPA data series as a measure of national demand for structural pine products a number of issues should be considered:

1) The data series does not include all domestic producers. As such, the series is a subset of national production or sales for all the domestic wood products analysed in this report. Accordingly, ABARES results should only be interpreted as estimates of the elasticities relating to producers included in the FWPA softwood data series.
2) The coverage of the data series—that is, the number of participating producers—changes over the sample period. Including additional participants over the sample period could

introduce spurious trends, affecting tests for stochastic trends as well as the estimated coefficients in the final models.

3) The data series contains 55 observations, which is smaller than ideal for the methods used. Small sample sizes increase uncertainty around coefficient estimates, which can lead to more variables being classified as statistically insignificant. Furthermore, some of the tests used to validate the in-sample properties of the models assume large sample properties of various estimators are valid for the dataset. This is less likely to be the case for smaller samples, rendering the tests potentially invalid.

With these issues in mind, the FWPA softwood data series provides the best available breakdown of softwood products data into structural and non-structural categories, including treated and untreated structural sawnwood products. In contrast, other measures of national sawnwood consumption and production include non-structural products that are out of scope for this report.

1.2.2 Timber and steel prices

To estimate own-price elasticities of demand, the domestic price index for MGP10 (Indufor 2017) was used to capture quarterly movements in the domestic price of structural pine. These price data may not necessarily reflect prices charged by individual producers or the average price charged by producers included in the FWPA softwood data series. Furthermore, the price data do not differentiate between treated and untreated prices. As a result, ABARES has assumed price changes are similar in magnitude across the two products.

Cross-price elasticities were estimated for steel using the ABS price index for steel beams and sections used in house construction (ABS 2017c) and estimated for imported structural timber using the average unit price for selected imported structural products (ABS 2017b). The ABS price index for steel beams and sections used in housing may include steel products that are not directly substitutable with structural pine framing. However, the ABS price index was considered the most appropriate dataset available in the absence of price data for specific steel frame products used in housing. ABARES attempted to refine the import series to products used specifically for structural applications and products disaggregated into treated and untreated categories. Because complete disaggregation was not possible, the import series should be considered an approximation of imported structural timber. For models of untreated and treated structural pine, the import price for untreated and treated structural pine imports were used. In contrast, for models of aggregate structural pine, the import price across all structural imports was used. Cross-price elasticities were not estimated for other materials (for example, concrete) because of the high degree of correlation among price series and lack of data.

1.2.3 Controlling for other factors

Control variables are included in the models to account for variations in demand due to non-price related factors. Although not the focus of this report, these variables control for potential biases in the estimates. Control variables include the number of detached and other residential dwelling commencements and the value of work done on new houses. Some models also include past changes in demand as explanatory variables.

A number of other explanatory variables were also considered but not included in the final models. This was because they were found to have little explanatory power (that is, they were found to be statistically insignificant) and including them had little effect on the estimated price elasticities, except to increase the standard error associated with the estimates. Variables found to be statistically insignificant included the value of residential alterations and additions, non-residential construction activity and the construction wage index. In many cases, the statistical insignificance of these variables was likely the result of a high degree of correlation with variables already included in the models, such as house commencements.

2 Results

Estimated results of price elasticities of demand for domestically produced structural pine across a range of models differing in structural form and estimation methods are shown in Table 2. Where multiple models provide estimates, a range is given. Detailed model results, including confidence intervals and coefficient estimates for all variables included in the models, are presented in Appendix B.

Table 2 Change in demand for domestically produced structural pine in response to 1 per cent change in timber and steel prices

Variables	Untreated structural pine (%)	Treated structural pine (%)	Aggregate structural pine (%)	Domestic share (%)
Domestic MGP10 price				
Current price	−1.28 to −0.06	−0.67 **b** to −0.54	−0.43 to −0.20	−0.38 **b**
Price from previous quarter	−0.58 **b**	−0.61 **b**	−0.55 **b**	−0.42 **b**
Price from two quarters prior	−0.23	−0.82 **b**	−0.08	−0.21
Imported structural pine prices a				
Current price	−0.13 to −0.01	−0.03 to 0.13	−0.01 to 0.14	0.30 **b**
Price from previous quarter	0.04	0.18	0.01	−0.03
Price from two quarters prior	0.14	−0.01	0.20	−0.06
Price of steel beams and sections used in housing				
Current price—whole period	−0.16 to 0.27	−0.41 to −0.39	−0.28 to 0.15	0.08
Current price —before September quarter, 2007	1.27 **b**	–	0.99 **b**	–
Current price—During and after September quarter, 2007	−0.16	–	−0.44	–
Price from previous quarter—whole period	−0.09	−0.54 **b**	−0.35	0.03
Price from two quarters prior—whole period	−0.36	0.18	−0.29	0.15

a Refers to the average import price of all structural pine products for models of aggregate structural pine; the average import price of untreated pine products for models of untreated structural pine; and the average import price of treated structural pine products for models of treated structural pine. **b** Estimate was statistically significant at the 95 per cent confidence level.

The estimates presented in Table 2 show the percentage change in demand for domestically produced structural pine in response to a 1 per cent change in price. For example, an estimate of −0.5 implies that a 1 per cent increase in prices for domestically produced structural pine reduces demand by 0.5 per cent. When considering cross-price measures, the sign of the coefficients indicates whether substitution or complementarity exists between domestically produced structural pine and the product of interest as a result of price changes. For example, a positive cross-price elasticity of demand implies that demand for structural pine rises with the price of the other material and, therefore, the two products are substitutes. A negative cross-price elasticity of demand implies demand for domestically produced structural pine falls with an increase in the price of the other material and the two goods are complements.

When interpreting the results, consideration should be given to the uncertainty around the estimated coefficients. For example, an estimate may be large in absolute terms but a high degree of uncertainty means it could easily have taken a different value had the sample been slightly different. Uncertainty around the estimated coefficients are reflected in the 95 per cent confidence intervals presented in Appendix B. These confidence intervals were used to determine whether each estimate was statistically significant—or statistically different from zero. Specifically, an estimate was determined to be statistically insignificant if the 95 per cent confidence interval around an estimate includes the value of zero. Statistical significance is an important concept because it implies that an estimate from a regression model is sufficiently robust to say with confidence a change is non-zero.

2.1 Responsiveness to domestic structural pine prices

2.1.1 Demand for untreated structural pine

Looking only at models of demand for untreated structural pine, the coefficient estimates on the current domestic price varied considerably, ranging between –0.06 and –1.28. That is, a 1 per cent increase in current domestic MGP10 prices was estimated to reduce demand for domestically produced untreated structural pine by between 0.06 and 1.28 per cent in the same period. Based on an assumed initial price of $3.40 per lineal metre and quarterly sales volume of 230,000 cubic metres, these estimates imply demand for domestically produced untreated structural pine could fall by between 400 and 8,650 cubic metres for every 10 cent increase in the lineal metre price of this product. The lower estimate (–1.28) was statistically insignificant.

For models of untreated structural pine that used changes in the domestic price from the previous one or two quarters, the coefficient estimates were –0.58 and –0.23, respectively. Only the lower estimate (–0.58) was statistically different from zero at the 95 per cent confidence level, suggesting the impact of prices on demand is most likely to be delayed by around one quarter. At an initial price of $3.40 per lineal metre and quarterly volume of 230,000 cubic metres, this implies that a 10 cent increase in lineal metre price of this product could reduce demand in the following quarter by around 3,900 cubic metres.

2.1.2 Demand for treated structural pine

For treated structural pine, the coefficient estimates on the current domestic price were relatively consistent across models, ranging between –0.54 and –0.67. That is, a 1 per cent increase in current domestic MGP10 prices was estimated to reduce demand for domestically produced treated structural pine by between 0.54 and 0.67 per cent in the same period. For example, at an initial price of $4.00 per lineal metre and quarterly volume of 220,000 cubic metres, these estimates imply demand for domestically produced treated structural pine could fall by between 2,950 and 3,700 cubic metres for every 10 cent increase in lineal metre price. The lower estimate (–0.67) was found to be statistically different from zero at the 95 per cent confidence level, implying that changes in domestic prices are likely to have a small, but immediate effect on demand for treated pine.

For models of treated structural pine that used changes in the domestic price from the previous one or two quarters, the coefficient estimates were –0.61 and –0.82 respectively. For example, at an initial price of $4.00 per lineal metre and quarterly volume of 220,000 cubic metres, the first estimates suggests every 10 cent increase in lineal metre price could reduce demand in the following quarter by around 3,350 cubic metres. The second estimates imply a 10 cent increase in lineal metre price could reduce demand in two quarters time by around 4,500 cubic metres.

Both of these estimates were statistically different from zero at the 95 per cent confidence level, implying that changes in domestic prices could have a delayed effect on demand for treated pine.

Including current and past changes in domestic price in the same model rendered all estimates statistically insignificant at the 95 per cent confidence level. These results provide mixed evidence around the potential time frame of effects.

2.1.3 Demand for aggregate structural pine

For models of aggregate structural pine, the coefficient estimates on the current domestic price of structural pine ranged from –0.20 to –0.43. That is, a 1 per cent increase in the current domestic MGP10 price is estimated to reduce demand for domestically produced structural pine by between 0.20 and 0.43 per cent. For example, at an initial price of $3.70 per lineal metre and quarterly volume of 440,000 cubic metres per quarter, these estimates imply that demand for domestically produced structural pine could fall by between 2,400 and 5,100 cubic metres for every 10 cent increase in lineal metre price. However, all estimates in this range were found to be statistically insignificant. As such, the estimates can be considered close to zero in absolute and statistical terms.

For models of aggregate structural pine that used changes in the domestic price from the previous one or two quarters, the coefficient estimates were –0.55 and –0.08 respectively. The former estimate (–0.55) implies that a 1 per cent increase in the previous quarter reduces demand in the current quarter by 0.55 per cent. For example, at an initial price of $3.70 per lineal metre and quarterly volume of 440,000 cubic metres, this suggests every 10 cent increase in lineal metre price could reduce demand in the following quarter by around 6,550 cubic metres. The lower estimate (–0.55) was found to be statistically different from zero at the 95 per cent confidence level, giving credence to the assertion that price changes are more likely to have a delayed, rather than immediate, impact on demand. The upper estimate (–0.08) was not statistically significant, suggesting that the delay between movements in prices and demand is unlikely to be two quarters in duration.

Overall, the results presented in Table 2 suggest short-term demand for structural pine products is likely to be relatively unresponsive to changes in prices, both in absolute and a statistical terms, because most estimates were not statistically different from zero. This suggests that domestic prices are unlikely to be the driving factor behind fluctuations in demand for structural pine, with other product prices and non-price factors being of greater importance.

2.2 Responsiveness to imported structural pine prices

2.2.1 Demand for untreated, treated and aggregate structural pine

Coefficient estimates on current imported structural pine prices ranged from –0.13 to –0.01 for models of untreated structural pine, from –0.03 to 0.13 for models of treated structural pine, and from –0.01 to 0.14 for models of aggregate structural pine. The changing signs across models provides an uncertain picture of the relationship between current import prices and demand for domestically produced structural pine. However, all of the results are close to zero and statistically insignificant at the 95 per cent confidence level. As such, the findings suggest that changes in current import prices are unlikely to have a material effect on demand for domestically produced structural pine.

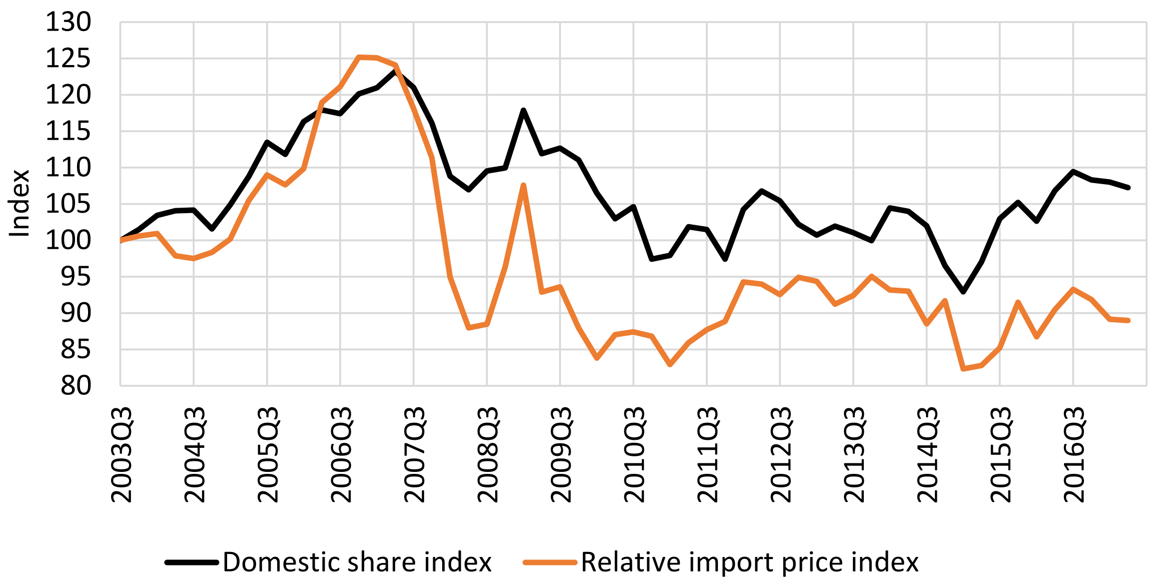
When changes in import prices from the previous one or two quarters were included instead of current import prices, the coefficient estimates ranged from –0.01 to 0.20 across all imported structural timber categories. All estimates were statistically insignificant, suggesting that, even when lagged effects are taken into account, import prices have little bearing on demand for domestically produced structural pine.

These results contradict anecdotal evidence of price-based substitution between domestically produced and imported structural pine products. However, this could be because imported and domestically produced structural pine products are material substitutes but may not be price substitutes. For example, long-term contracts with domestic suppliers and comparative order lead times can limit substitution, with domestic suppliers having a distinct advantage in most cases. It may also be because there are costs associated with switching between suppliers, causing buyers to hold off substituting between domestic and imported varieties until the observed price changes are seen as more permanent.

2.2.2 Domestic market share

Changes in the price of imported structural pine products may have little effect on the total demand for domestically produced structural pine, but changes in the relative price of imported and domestically produced structural pine appear to be strongly correlated with change in the share of imports in consumption (Figure 1). This observed relationship between relative prices and relative market share led ABARES to consider models of the share of domestic consumption of structural pine met by domestic production, referred to as the 'domestic market share'.

Figure 1 Relative import price and domestic market share in total consumption



Note: Q3 refers to September quarter.
Source: ABS 2017b; FWPA 2018

As expected, ABARES found that changes in the current domestic price of MGP10 reduced the share of domestic consumption supplied by domestic production. Specifically, ABARES estimates that a 1 per cent increase in the current domestic price of MGP10 reduces the domestic market share by 0.38 per cent and a 1 per cent increase in price from the previous quarter reduces the domestic market share by 0.42 per cent. These estimates imply that, at an initial price of $3.70 per lineal metre and market share of 75.2 per cent, a 10 cent increase in the current domestic MGP10 price could reduce the domestic market share in the same period by around 1.0 per cent or, in the following period, by around 1.1 per cent, depending on the model used.

While changes in import prices may have little effect on the level of total demand for domestically produced structural pine (see section 2.2.1), ABARES found evidence that changes in current import prices do affect the share of domestic demand for structural pine met through domestic production. This is consistent with changes in import prices only affecting demand for imported timber. Specifically, a 1 per cent increase in import prices was estimated to increase the domestic market share by 0.30 per cent. At an initial import price of $540 per cubic metre and domestic market share of 75.2 per cent, this implies that a $20 increase in average import prices could increase the domestic market share in the same period by around 1.1 per cent. However, past price changes were estimated to have a negligible effect on the domestic market share, indicating no lagged response of the domestic market share to changes in the relative import price.

2.3 Responsiveness to steel prices

In developing models of demand for domestically produced structural pine, ABARES found that the sensitivity of demand to changes in the price of steel beams and sections varied considerably over time. This lead ABARES to consider models of demand for domestically produced structural pine that allowed the estimated coefficient for steel prices to change at a fixed point in time. Preliminary tests indicated the most probable date of a structural break was the September quarter of 2007, just before the global financial crisis and associated spike in steel prices. Examination of the series found steel prices in the model behaved differently before and after this period, justifying the inclusion of a structural break in the models. However, results are also presented for models that include no structural break as a reference point.

2.3.1 No structural break

For models that did not consider a structural break, the coefficient estimates for current steel prices ranged from –0.41 to 0.27 across the three categories of demand. Most estimates had a negative sign, implying an increase in steel prices is associated with a decrease in demand for structural pine, which contradicts the assertion that steel and timber framing are substitutes. However, a large degree of uncertainty surrounded the estimates, with all estimates being statistically insignificant at the 95 per cent confidence level, suggesting current steel prices likely have little to no effect on demand for structural pine.

For models that used changes in steel prices from the previous one or two quarters, the coefficient estimates ranged between –0.54 to –0.09 at the one quarter lag, and between –0.36 and 0.18 at the two quarter lags. The estimates for the one quarter lag were statistically significant for models of treated structural pine (–0.54). However, when the spike in steel prices in the September quarter of 2008 (Box 1) was excluded from the model, the coefficient estimate became statistically insignificant. In contrast, the estimates for the two quarter lags were insignificant across all models. As such, even when lagged effects of price changes on demand are taken into account, steel prices are unlikely to have a material impact on demand for domestically produced timber in the short-run.

2.3.2 With structural break

When a structural break with respect to steel prices was included in the model, the estimated impact of steel prices on demand for structural pine changed. Models with a structural break were not estimated for treated structural pine because there was no evidence of a structural break with respect to steel prices for treated structural pine. That is, tests indicated no statistical difference between the coefficient estimates on steel prices before and after any date over the sample period for treated pine. For the models that included a structural break with respect to steel prices, only current prices were used because no evidence of changing coefficient estimates on lagged prices was found.

For the model of untreated structural pine with a structural break, the estimated elasticities with respect to steel prices before the September quarter of 2007 were 1.27 and after the September quarter of 2007 were –0.16. This implies that a 1 per cent increase in steel prices before the September quarter of 2007 increased demand for domestically produced untreated structural pine by 1.27 per cent and a 1 per cent increase in steel prices at or after the September quarter of 2007 reduced demand for domestically produced untreated structural pine by 0.16 per cent.

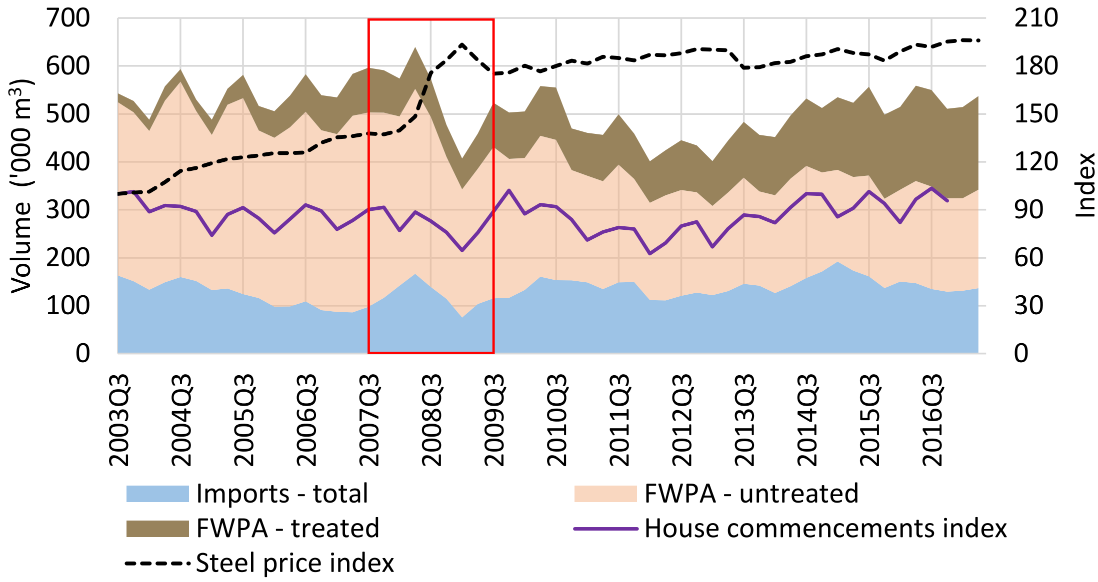
For the model of aggregate structural pine with a structural break, the estimated elasticities with respect to steel prices were 0.99, before the September quarter of 2007, and –0.44 after. This implies that a 1 per cent increase in steel prices before the September quarter 2007 increased demand for domestically produced structural pine by 0.99 per cent and a 1 per cent increase in steel prices during or after the September quarter of 2007 reduced demand for domestically produced structural pine by 0.44 per cent.

In both models the estimated coefficients before the September quarter of 2007 (1.27 for untreated, 0.99 for aggregate) were statistically significant. In contrast, estimated coefficients after the September quarter of 2007 were both insignificant, suggesting steel prices had a greater effect on demand for domestically produced structural pine before the September quarter of 2007 than afterwards.

Box 1 Structural pine sales

Figure 2 compares the volume of structural pine sales with steel prices, and house commencements, between the September quarter of 2003 and the June quarter of 2017. The increased volatility between the September quarters of 2007 and 2009 corresponds to the global financial crisis (GFC).

Figure 2 Structural pine sales and steel price indexes



Note: Q3 refers to September quarter.
Source: ABS 2017a, b, c; FWPA 2018

From the September quarter of 2003 to the September quarter of 2007 domestic demand for structural pine and steel prices grew steadily and house commencements remained constant. Upward movements in both steel prices and demand for structural pine are consistent with substitution between structural pine and steel based on prices.

From the September quarter of 2007 to the September quarter of 2009, steel prices and structural pine sales start to move in opposite directions. Steel prices increased by 40 per cent from the September quarter of 2007 to the March quarter of 2009 before falling 9 per cent to the September quarter of 2009. Over the same period, sales of domestically produced structural pine decreased by 24 per cent from the September quarter of 2008 to the March quarter of 2009 before increasing 23 per cent to the September quarter of 2009.

Opposite movements in domestic structural pine sales and steel prices are consistent with steel and structural pine products being substitute goods but not necessarily imply that this is the case. House commencements appear to explain a great deal of variation in sales during and after the GFC, but not before.

2.4 Comparisons with previous studies

2.4.1 Australian studies

Few studies have reported estimates of price elasticities of demand for structural timber in Australia, especially in recent years. Doran and Williams (1982) provide the most recent estimates using a cost function approach for the residential construction industry over the period 1956–57 to 1976–77. Estimates of the price elasticity of demand for timber used in housing with respect to domestic and imported timber prices are presented in Table 3, along with a range of estimates derived by ABARES.

Table 3 Estimates of price elasticities of demand for timber used in housing, Australia

Study	Time period	Own price elasticities (%)	Cross price elasticities with respect to imported timber price (%)
Doran & Williams (1982)	1956–57	0.40	–0.15
	1961–62	0.47	–0.23
	1966–67	0.34	–0.28
	1971–72	0.01	–0.39
	1976–77	–0.40	–0.38
This study (ABARES)—untreated structural pine	Q4 2003–Q2 2017	–1.28 to –0.06	–0.13 to 0.14
This study (ABARES)—treated structural pine	Q1 2006–Q4 2016	–0.82 to –0.54	–0.03 to 0.18
This study (ABARES)—aggregate structuration pine	Q4 2003–Q2 2017	–0.55 to –0.08	–0.01 to 0.20

Note: Q1 refers to March quarter, Q2 June quarter, Q3 September quarter and Q4 December quarter.

Doran and Williams (1982) estimates own price elasticities of –0.40 to 0.47 over the period 1956–57 to 1976–77, decreasing over time. Early in the period the estimated elasticities were positive, implying that increases in timber prices increased demand for timber. They noted the estimates are likely to have been biased upwards due to the omission of steel and wood panel prices from the model. In later years, the estimates are negative and more in line with ABARES results and expectations.

Doran and Williams' (1982) estimates of price elasticities of demand with respect to import prices were negative, indicating that imported timber and domestically produced timber are complements rather than substitutes. However, over the sample period domestic timber used in housing was predominantly hardwood and imported timber was primarily softwood. As such, the domestically produced and imported timber had different physical properties and were therefore not material substitutes.

Ignoring any bias, these previous estimates imply demand for timber is somewhat unresponsive to price changes. The range of ABARES estimates of own-price elasticities of structural pine demand are broadly consistent with these findings albeit somewhat lower. However, taking into account the downward trend in estimated elasticities over time and potential bias, ABARES estimates appear to be consistent with what might be expected using more recent data.

2.4.2 International studies

Numerous studies present estimates of price elasticities of demand for structural timber in other countries. The majority of these studies focus on demand in North American markets, and employ a range of estimation methods, assumptions and datasets (Table 4 and Table 5).

Table 4 Estimates of own-price elasticities of demand for softwood sawnwood, international

Source	Time frame	Comments	Elasticity estimate (%)
McKillop, Stuart & Geissler (1980)	1953–1974	US softwood lumber wholesale price index	–0.17
Waggener, Gerard & Howard (1978)	1950–1974	US softwood lumber price	–0.35
Adams (1977)	1947–1974	US softwood lumber price index, 1 year lag	–0.08
Spelter (1985)	1950	US softwood lumber price	–0.29
	1960		–0.16
	1970		–0.13
	1980		–0.11
	1950–1954	US softwood lumber price	–0.88
			–0.39
Rockel & Buongiorno (1982)	1970–1974	US Douglas fir wholesale price index	–0.91
Robinson (1974)	1968–1977	Douglas fir price	–0.88
Gellner, Constantino & Percy (1990)	1979–1984	US softwood lumber price	–0.38
		Canadian softwood lumber price	–0.54
Uri & Boyd (1991)	1950–1985	Softwood lumber estimates across all US regions	–0.34
Adams, Boyd & Angle (1992)	1950–1987	Residential construction	–0.55
		Non-residential construction	–1.15
Soria (2005)	2004	Multiple species—wall framing application	–1.85 to –1.48
		Multiple species—roof framing application	–0.84 to –0.72
		Multiple species—floor framing application	–0.95 to –0.78
Nagubadi et al. (2004)	January 1989 – July 2001	US untreated lumber	–0.70
		US treated lumber	–1.80
This study (ABARES)	Q4 2003–Q2 2017	Australian demand for domestically produced untreated structural pine	–1.28 to –0.06
	Q1 2006–Q4 2016	Australian demand for domestically produced treated structural pine	–0.82 to –0.54
	Q4 2003–Q2 2017	Australian demand for domestically produced aggregate structural pine	–0.55 to –0.08

Note: Q1 refers to March quarter, Q2 June quarter, Q3 September quarter and Q4 December quarter.

The estimated elasticities of demand with respect to timber prices ranges from –1.85 to –0.08 (Table 4), with the majority of results greater than –0.55. The results presented in this paper fall within this range and reinforce the findings that demand for structural timber tends to be inelastic with respect to timber prices.

Estimates of cross-price elasticities of demand for timber with respect to steel and imported timber prices are presented in Table 5. Estimates range from –0.08 to 0.37 for the studies listed, indicating some price substitution between domestically produced timber and imported timber and steel. These estimates fall within the range of estimates presented by ABARES in this chapter.

Table 5 Estimates of cross-price elasticities of demand for softwood sawnwood, international

Source	Time frame	Comments	Elasticity estimate (%)
McKillop, Stuart & Geissler (1980)	1953–1974	US galvanised carbon steel sheet price index	0.37
Rockel & Buongiorno (1982)	1970–1974	Amalgamated price series (including steel, brick and cement data)	0.09
Spelter (1985)	1950	US demand for wood products with respect to steel prices in the non-residential sector.	0.03
	1960		0.02
	1970		0.01
	1980		0.01
Nagubadi et al. (2004)	January 1989–July 2001	US demand for imported Canadian timber in response to price changes in domestically produced untreated timber	0.23
		US demand for imported Canadian timber in response to price changes in domestically produced treated timber	0.00
This study (ABARES)	Q4 2003–Q2 2017	Australian demand for domestically produced aggregate structural pine in response to changes in the price of steel beams and sections used in housing	–0.54 to 0.18
		Australian demand for domestically produced aggregate structural pine in response to changes in imported structural timber prices	–0.01 to 0.20

Note: Q1 refers to March quarter, Q2 June quarter, Q3 September quarter and Q4 December quarter.

3 Non-price determinants of demand for structural pine

The estimates presented in Chapter 2 suggest that timber and steel prices are not the major determinant of demand for domestically produced structural pine products in the short-run. This chapter discusses the importance of residential construction activity and other non-price factors as alternative determinants of changes in demand.

3.1 Residential construction activity

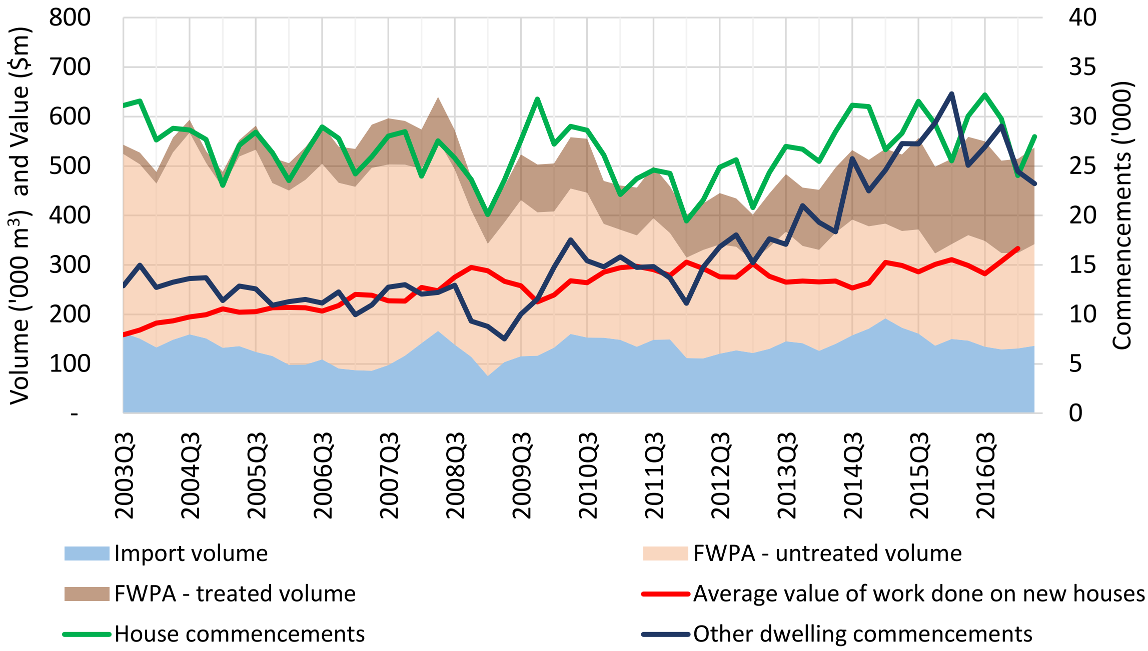
Structural pine products are used primarily in the construction of new residential buildings and alterations to existing homes. The most common application of structural pine products is roof and wall framing in the construction of detached houses. In 2009, 74 per cent of new Australian residential dwellings were constructed with timber wall framing and 89 per cent were constructed with timber roof framing (Kapambwe et al. 2009). The majority of this timber is likely softwood, but the proportion of softwood and hardwood used varies across states. For example, softwood likely accounts for almost all timber used in residential construction in South Australia but only around half in Tasmania (Kapambwe et al. 2009).

3.1.1 New houses and other residential dwelling commencements

From the September quarter of 2003 to the September quarter of 2017, quarterly fluctuations in demand for domestically produced structural pine appear to have closely matched house commencements (Figure 3). Dwelling commencements are typically highest in the September quarter (winter) and lowest in the March quarter (summer), with softwood pine sales following a similar pattern. In contrast, the volume of structural pine imported does not follow the same seasonal cycle as house commencements, suggesting possible different drivers of the volume of imported structural pine.

In addition to the number of new dwelling commencements, house sizes also play a role in total timber consumption. For example, over the period 2000–01 to 2008–09, estimated average timber use per dwelling declined between 5 per cent and 19 per cent across the states and territories (Kapambwe et al. 2009). The decline in timber use per dwelling reflects changes in architectural styles and substitution of timber for other materials. New, more efficient, construction techniques have been developed that require fewer resources and stronger and more durable materials have been introduced. Inroads are also being made by timber competitors, particularly steel and concrete, replacing timber over time in some areas. For example, concrete slabs now account for 80 per cent of foundations used in new houses, with cost and time constraints being cited as the main reasons for this shift (Kapambwe et al. 2009). Although these trends were observed almost a decade ago, ABARES has assumed the general trends observed will have continued to the present day.

Figure 3 Structural pine sales and housing activity, December 2003 to June 2017



Note: Q3 refers to September quarter. Value of new houses refers to value of work done.
Source: ABS 2016a, b; FWPA 2018

3.1.2 Estimates of demand responsiveness to residential construction activity

New house commencements, other residential unit commencements and the value of work done on new houses were included as explanatory variables in all models of demand estimated (see Appendix A). Estimates of the responsiveness of demand for domestically produced structural pine with respect to these variables are shown in Table 6.

Table 6 Change in demand for domestically produced structural pine in response to 1 per cent change in residential construction activity, various measures

Variables	Untreated structural pine (%)	Treated structural pine (%)	Aggregate structural pine (%)
House commencements **a**	0.36 to 0.64	0.77 to 0.99	0.48 to 0.69
Other residential commencements	0.04 to 0.09	0.02 to 0.08	0.04 to 0.08
Value of work done on new houses	0.14 to 0.31	0.00 to 0.33	0.26 to 0.44 **b**

a All estimates were statistically significant at the 95 per cent confidence level. **b** Some estimates in this range were statistically significant at the 95 per cent confidence level.

Demand for domestically produced untreated structural pine was estimated to increase by between 0.36 and 0.64 per cent for every 1 per cent increase in detached house commencements. The estimates are higher for treated structural pine (0.77 to 0.99 per cent) and aggregate structural pine (0.48 to 0.69 per cent). In contrast to coefficient estimates for timber and steel prices presented in Chapter 2, all coefficient estimates for new house commencements were statistically significant at the 95 per cent confidence level, indicating that the number of new house commencements is a reliable predictor of structural pine sales.

In contrast, demand for domestically produced untreated structural pine was largely unaffected by the number of other residential commencements. For example, demand for untreated structural pine was estimated to increase by between 0.04 and 0.09 per cent for every 1 per cent increase in other residential commencements. The estimates were similar for treated structural pine (0.02 to 0.08 per cent) and aggregate structural pine (0.04 to 0.08 per cent). All coefficient estimates for other residential commencements were statistically insignificant at the 95 per cent confidence level, indicating that the number of other residential commencements likely has little impact on total demand for domestically produced structural pine. This is consistent with other materials, such as steel and concrete, being predominately used in multi-storey construction.

The value of work done on new houses (a proxy for house size when divided by the number of new houses) potentially accounts for unexplained variations in structural pine sales because larger homes require more materials. For example, between the March quarter of 2002 and December quarter of 2008 structural pine sales grew from 350,000 cubic metres to 600,000 cubic metres per year, although house commencements declined slightly. Over the same period the average value of work done on new houses increased from $138,000 to $295,000. From the March quarter of 2009 the average value of work done per new house has remained relatively stable, with structural pine sales matching house commencements closely.

Demand for domestically produced structural pine is estimated to increase by between 0.14 and 0.31 per cent for every 1 per cent increase in the value of work done on new houses (Table 6). The estimates are similar for treated structural pine (0.00 to 0.33 per cent) and slightly higher for aggregate structural pine (0.26 to 0.44 per cent). Estimates for models of untreated and treated structural pine were all insignificant at the 95 per cent confidence level. However, this could be because the value of work done is an imperfect measure of house size and other factors such as labour costs may play a more important role.

3.2 Other non-price factors

3.2.1 Short-term drivers

Other non-price factors may help explain why changes in relative prices between materials is not necessarily matched by a corresponding change in consumption. For example, long order lead times impose costs on builders, including construction downtimes, having to turn down potential projects and difficulty planning for the future. Differences in order lead times can offset any advantage of using a particular material based on prices alone. Material properties also play an important role in the choice of construction system and can easily outweigh material prices when labour costs are taken into account. For example, timber is the dominant material in housing construction partly because its properties (light, malleable and adaptable) make it easier to work with on confined sites. Also, offsite prefabrication (of timber frames, for example) can reduce build times and onsite flexibility can minimise delays. This has implications for build times and ultimately labour costs (Cunningham 2013). When these additional factors are taken into account, a large price differential may be required before substitution between materials occurs.

3.2.2 Long-term drivers

Environmental issues are becoming increasingly important, and consumers may place more weight on the environmental properties of various construction systems and materials. For example, moves by the housing construction industry to reduce onsite waste and the greater awareness of timber as a green alternative to concrete and steel, including its ability to store carbon (Mitchell & Tucker 2011), may affect consumers' purchasing decisions.

Changing consumer preferences also affect the choice of construction system. Consumers are increasingly opting for open plan houses, which require fewer internal walls, decreasing the required amount of material inputs. However, this means that structural construction systems need to be stronger, placing a greater emphasis on strength and durability of the material used.

Recent changes to the National Construction Code have opened the way for increased timber use in the midrise construction market, leading to greater timber use in multi-level buildings (Bleby 2016). Overseas commentators report that the benefits outlined for housing construction exist for taller constructions as well, with changes to building codes likely to have a large effect on demand for timber in the future (Donahue 2016; Tollefson 2017). This has been observed domestically in the high rise construction industry, where engineered wood products are increasingly being used.

Socio-demographic trends are also likely to have a large effect on the types of homes built and total timber demand. A global trend towards higher-density living (World Bank 2017 that reflects infrastructure constraints, urban sprawl resistance and changing demographics will likely promote a shift from class one buildings (small residential properties) to higher multi-unit buildings. The market for multi-unit dwelling construction is likely to be more competitive in terms of materials being used because structural constraints, regulatory factors, material costs and different building practices have a greater bearing on decisions about material choice (Black 2014).

Conclusion

The analysis in this report presents estimates of the responsiveness of demand for domestically produced structural pine to changes in timber and steel prices. Based on ABARES findings, increases in the domestic price of structural pine reduce demand for domestically produced structural pine, but the magnitude of the impact is only moderate and the majority of results were not statistically significant. For example, in most cases a 1 per cent increase in the domestic price of structural timber reduced demand by less than 1 per cent. ABARES estimates suggest that changes in domestic prices are more likely to have a delayed, rather than immediate, impact on demand.

Changes in prices for imported structural pine products appear to have a negligible effect on demand for domestically produced structural pine but a statistically significant impact on the domestic market share in total consumption of structural pine. As a result, although the relative import price provides little insight into the overall demand for domestically produced structural pine, it does explain changes in market share.

The effect of changes in the price of steel beams and sections used in housing construction on the demand for domestically produced structural timber was highly sensitive to model assumptions. The price of steel beams and sections used in housing construction was estimated to have a negative effect on demand for domestically produced structural pine over the sample period. That is, increases in steel prices reduced demand for domestically produced structural pine. These results were all statistically insignificant at the 95 per cent confidence level, which suggests that the price of steel beams and sections could have a limited impact on demand for domestically produced structural pine. When the responsiveness of demand to steel prices was allowed to change over the sample period, there was evidence of strong price substitution between steel and structural pine before the September quarter of 2007 (the beginning of the global financial crisis).

These estimates, may be somewhat affected by the use of the ABS price index for steel beams and sections used in housing. This index contains a range of steel products, some of which may not be direct substitutes for structural pine. However, overall, the estimated price elasticities of demand for structural pine were largely consistent with previous studies, both in Australia and internationally.

The estimates in this report suggest that the effect of timber and steel prices on demand for domestically produced structural pine is limited in the short-run. However, residential construction activity was found to have a substantial and statistically significant effect on demand for domestically produced structural pine products in all of the estimated models. In particular, new house commencements explain a great deal of the quarter-on-quarter changes in domestic structural pine sales. This confirms the common assertion that house commencements are the primary driver for structural timber demand within Australia.

Looking forward, changes in consumer preferences, socio-demographic trends and building regulations will likely play a much greater role in the choice of building materials used in housing construction compared with timber and steel prices. Trends suggest consumers are placing more weight on the environmental benefits of structural materials. Changing architectural styles will change the material requirements for a standard home. A global trend towards higher-density living will likely promote a shift toward multi-unit buildings, with recent changes to the National Construction Code opening the way for increased timber use in the midrise construction market.

Appendix A: Building models of demand

ABARES tested a large number of models with varying functional forms and combinations of explanatory variables to estimate price elasticities of demand. The primary estimation method used in this report is ordinary least squares (OLS). However, two-stage least squares (TS) was also used to test and account for simultaneous endogeneity with respect to domestic prices. The models of demand estimated are based on historical relationships between the FWPA softwood data series and various explanatory variables. This section outlines the datasets and methods used to build models of demand and verify their statistical robustness.

Types of models of demand

The econometric models of demand estimated in this report are linear approximations of industry-level demand functions. By taking the natural logarithm of demand and price variables, the signs and magnitudes of the coefficients represent the sensitivity, or elasticity, of industry demand to various factors. A log-log model is also consistent with the assumption that price elasticities of demand do not change with the overall quantity demanded.

Table A1 outlines the four different types of models estimated across the three categories of demand. All models include a constant, seasonal dummy and one or more control variables with respect to construction activity. In contrast to the simple (S) models, the dynamic (D) models also include past changes in demand and prices as explanatory variables and the structural break (B) models allow the elasticity of demand with respect to steel prices to change at a fixed point. TS models refer to the use instrumental variables to test and account for price endogeneity using two-stage least squares estimation methods and the market share (SH) models estimate changes in the share of domestically produced structural pine in total consumption.

Table A1 Types of models of demand

Model types	Description
S (simple models)	The simplest models of demand with no past changes in demand or prices included as explanatory variables. Price elasticities are assumed to be constant over the sample period.
D (dynamic models)	Include past changes in demand and past changes in prices as explanatory variables to capture potential dynamics.
B (structural break models)	Allow changes in the price elasticities of demand at specific dates. Tests indicated a structural break was only applicable to steel prices for demand for aggregate and untreated pine.
TS (two-stage least squares models)	Used to test and account for potential price endogeneity. Past changes in the domestic MGP10 price are used as an instrument for current changes (see discussion on two-stage least squares). Only estimated for untreated structural pine sales.
SH (market share models)	Models of the share of domestically produced structural pine in total consumption as opposed to level of demand.

For the dynamic (D) models, changes in demand up to four quarters before the current period and price changes up to two quarters before the current period were considered as explanatory variables. Including past changes in demand allows the estimation of long-run elasticities of demand because a price change in one period can have ongoing implications for demand in future periods. Including past changes in prices assumes changes in prices have a delayed and short-lived impact on demand.

Structural break models were only estimated for aggregate demand for domestically produced structural pine and demand for untreated structural pine. This is because there was no evidence of a structural break with respect to steel prices in the case of demand for treated structural pine.

For the two-stage least squares models (TS) the domestic price was replaced with fitted values from a regression of domestic prices on other explanatory variables in the model plus past changes in domestic prices. A two-stage least squares model was only estimated for untreated structural pine demand as preliminary regressions indicated no evidence of price endogeneity for aggregate or treated structural pine demand.

Statistical robustness

ABARES considered a large number of models with varying functional forms and combinations of explanatory variables to estimate elasticities of demand. The model results presented in Chapter 2 represent the broad range of models.

In developing candidate models, ABARES preferred models with fewer variables and simpler dynamics. Smaller models have an advantage over larger models because they maintain higher degrees of freedom, which is important when the sample size is small (as in this report). The model specification procedure considered deterministic terms (such as seasonal dummies and trends) and time series processes (including auto-regressive and moving average processes).

ABARES models were considered to have acceptable in-sample properties if assumptions required for consistent coefficient and variance estimates appeared to be met with an acceptable level of probability (meaning, the estimates were statistically robust). For example, least squares estimates are inefficient and any related inferences become invalid when residuals exhibit heteroscedasticity or autocorrelation. Furthermore, estimates are biased when models are incorrectly specified or explanatory variables are endogenous. In all cases, diagnostic tests determined whether prerequisite assumptions for efficient estimation and valid inference were met in the candidate models.

ABARES conducted residual diagnostic tests for autocorrelation, including the Breusch-Godfrey LM test (Breusch 1978; Godfrey 1978) and Ljung-Box Q-statistics (Ljung & Box 1978); and diagnostic tests for heteroscedasticity, including the Breusch-Pagan-Godfrey test (Breusch & Pagan 1979; Godfrey 1978) and White test (White 1980). The Ramsey RESET test (Ramsey 1969) was used to simultaneously test for inappropriate transformations of the dependent variable, endogenous regressors and incorrect functional form. Influential observations and outliers were identified using studentised residuals and DFFITS (Belsley, Kuh & Welsh 1980). The presence of structural breaks and associated dates were determined using the Bai Perron sequential breakpoint methodology (Bai 1997).

Testing for stochastic trends

Like many economic series, all of the time series used in this report were found to be non-stationary. That is, the series contain trends that prevent them from reverting to a long-run mean level over time. These trends may be deterministic in nature, where the series increase or decrease over time in a predictable way, or random (stochastic) in nature, where series tend to increase or decrease randomly each period. Standard estimation procedures have been shown to be invalid in the presence of stochastic trends. To determine if any transformation must be applied to the series before estimation, the type of trend underlying the series must be identified.

The HEGY test
With quarterly data, unit roots may exist at the quarterly, semi-annual and annual frequencies. The presence of seasonal and non-seasonal unit roots were tested for using the HEGY procedure (Hylleberg et al. 1990). The procedure involves estimating equation A1 and testing statistical significance of the γ coefficients. The statistical significance of γ1 and γ2 indicate no unit roots at the quarterly or semi-annual frequencies, and the joint significance of the coefficients γ3 and γ4 indicate no unit root at the annual frequency.

Equation A1 HEGY unit root test regression

$$\Delta_4 y_t = constant + \alpha_1 s_1 + \alpha_2 s_2 + \alpha_3 s_3 + \beta trend + \gamma_1 y_{1,t-1} - \gamma_2 y_{2,t-1} - \gamma_3 y_{3,t-1} - \gamma_4 y_{3,t-2} + lags$$

Where:

$\Delta_4 y_t = y_t - y_{t-4}$

$y_{1,t-1} = y_{t-1} + y_{t-2} + y_{t-3} + y_{t-4}$

$y_{2,t-1} = y_{t-1} - y_{t-2} + y_{t-3} - y_{t-4}$

$y_{3,t-1} = y_{t-1} - y_{t-3}$

$y_{3,t-2} = y_{t-2} - y_{t-4}$

s_1, s_2 and s_3 refer to orthogonalised seasonal dummies for the March, June and September quarters, respectively.

trend refers to a deterministic trend.

lags refer to lags of $\Delta_4 y_t$.

The number of lags of $\Delta_4$yt included in the test equations has been shown to affect the validity of the results; with too few lags resulting in residuals not having white noise properties (rendering inference invalid) and too many lags reducing the power of the test (that is, concluding the presence of unit roots when there are none). To determine the appropriate number of lags, test regressions were run with up to eight lags. The decision on how many lags to include was based on residual criterion results.

The test statistics do not have standard distributions and depend on the deterministic terms included in the equation. Deterministic terms may include a constant, seasonal dummies and a linear trend. Seasonal dummies were included for series that exhibited annual cycles, otherwise only a constant and trend were considered. Where seasonal dummies were included, centred or orthogonalised seasonal dummy variables were used that shift the mean of the series without contributing to the trend. Critical values for various combinations of deterministic variables are summarised in Table A2.

Many of the test regressions had one or more outliers, or highly influential observations, as indicated by the studentised residual statistic. These observations were removed from the sample and the testing procedure was repeated. Both sets of results are presented where this has occurred.

Table A2 Critical values for HEGY test (48 observations)

Deterministic variables	Non-seasonal unit root				Semi-annual unit root				Seasonal unit root			
	1%	2.5%	5%	10%	1%	2.5%	5%	10%	1%	2.5%	5%	10%
C+T+SD	−4.46	−4.04	−3.71	−3.37	−3.80	−3.41	−3.08	−2.73	9.27	7.7	6.55	5.37
C+SD	−3.77	−3.39	−3.08	−2.72	−3.75	−3.37	−3.04	−2.69	9.22	7.68	6.6	5.5
C+T	−4.23	−3.85	−3.56	−3.21	−2.65	−2.24	−1.91	−1.57	4.64	3.7	2.95	2.23
C	−3.66	−3.25	−2.96	−2.62	−2.68	−2.27	−1.95	−1.60	4.78	3.78	3.04	2.32

Note: **C** Constant variables. **SD** Centred seasonal dummy variables. **T** Trend variables.
Source: Hylleberg et al. 1990

Table A3 summarises results from the preliminary HEGY test regressions for the various series. The reported figures are the test statistics for the γ coefficients. Test statistics that are insignificant at the 95 per cent confidence level are indicative of a unit root at that frequency.

The majority of series tested showed evidence of at least a non-seasonal unit root (unit root at the quarterly frequency). The non-residential commencements series and the alterations series both displayed signs of unit roots at different frequencies. All the series have been tested at the limited sample size available to ABARES. In this case that meant testing from the September quarter of 2003 through to the March quarter of 2017, which is the length of our shortest series. This limited number of observations had notable effects on the results for some of the series. This is not surprising given the length of some of the series being considered.

Price endogeneity and two-stage least squares

In estimating econometric models of demand all explanatory variables are assumed to be exogenous, or unaffected by changes in demand. In practice, prices and demand are often determined simultaneously through equilibration of demand and supply. This price endogeneity makes estimation of price elasticities of demand problematic because shifts in demand, in response to unobserved non-price factors (the error term), may be positively correlated with changes in prices. As a result, estimates of demand elasticities using OLS are biased upward or biased toward zero since demand elasticities are typically negative.

To test for and address price endogeneity ABARES used two-stage least squares. This method involves replacing the endogenous price variable with another variable (referred to as an instrument) that is correlated with domestic prices but uncorrelated with unobserved factors that affect demand. Using this method, changes in the price instrument can be interpreted as pure movements along the demand curve. The difficulty in using the instrumental-variables technique is obtaining a suitable set of instruments. The analysis in this report uses the previous quarter change in price as an instrument for current changes in prices.

ABARES formally tested for endogeneity in the domestic price of timber using the Durbin–Wu–Hausman test (Table A4). The tests indicated no presence of endogeneity in the case of total demand for treated structural pine but indicated potential endogeneity in some models of untreated timber demand. As a result, prices may be used in short-run models of aggregate timber demand and treated timber to produce unbiased estimates of price elasticities, but may not be appropriate for untreated timber demand. However, given the mixed results for untreated demand, TS and OLS are both considered for untreated timber demand. Biased OLS estimates may still be preferable to consistent two-stage least squares estimates in small samples.

Table A3 HEGY test critical values and test statistics

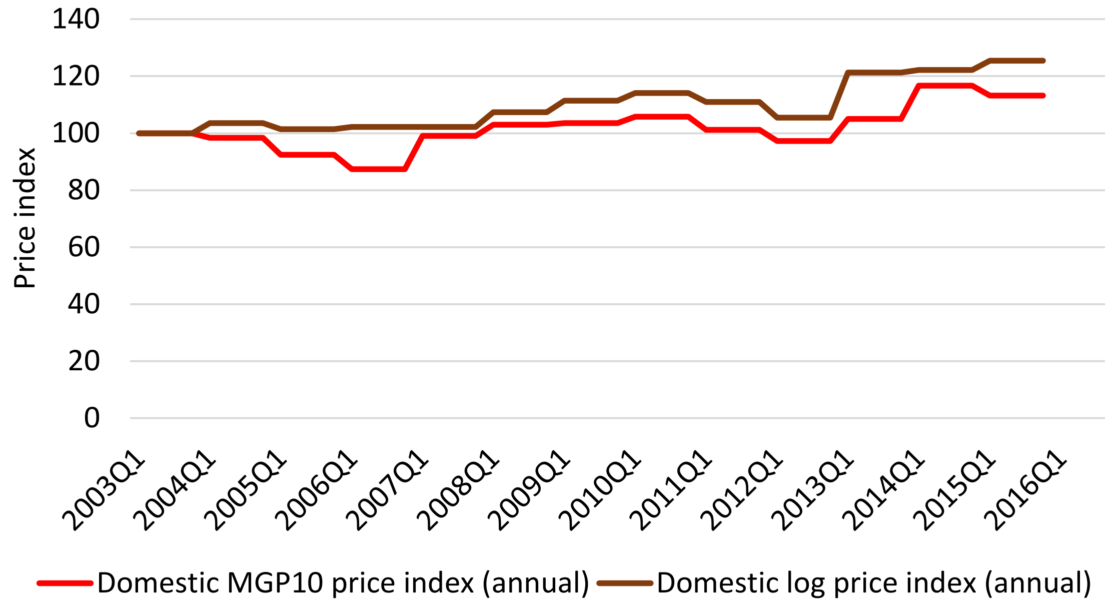
Series	Excluded observations	Lags	Deterministic	Critical values Non-seasonal	Semi-annual	Annual	Appropriate difference filter
FWPA	None	1	C + SD	−1.24 **a**	−3.27	17.62	Quarterly
		1	C + T + SD	−1.15 **a**	−3.23	16.75	Quarterly
MGP10	None	0	None	0.54 **a**	−2.46	69.00	Quarterly
		0	C	−1.80 **a**	−2.53	70.61	Quarterly
		0	C + T	−3.15 **a**	−2.62	72.73	Quarterly
Import price	None	1	None	0.46 **a**	−3.86	14.11	Quarterly
		0	C	−1.48 **a**	−3.76	16.76	Quarterly
		1	C + SD	−1.04 **a**	−3.65	12.62	Quarterly
		0	C + T	−1.30 **a**	−3.69	16.25	Quarterly
		0	C + T + SD	−1.23 **a**	−3.49	15.78	Quarterly
Steel	None	0	None	1.81 **a**	−3.74	27.98	Quarterly
		0	C	−2.21 **a**	−3.54	26.66	Quarterly
		0	C + T	−1.49 **a**	−3.53	26.15	Quarterly
House commencements	None	0	C + SD	−2.69 **a**	−3.85	24.32	Quarterly
		0	C + T + SD	−2.70 **a**	−3.77	23.16	Quarterly
Other commencements	None	0	C + SD	−0.97 **a**	−3.83	22.80	Quarterly
		0	C + T + SD	−2.72 **a**	−3.99	22.79	Quarterly
Value of non-residential work done (total)	None	1	C + SD	−4.36	−5.22	25.45	None
		1	C + T + SD	−2.53 **a**	−5.16	24.88	Quarterly
Value of alterations	None	0	C + SD	−0.69 **a**	−2.51 **a**	30.00	Semi-annual
		0	C + T + SD	−2.18 **a**	−2.63 **a**	31.18	Semi-annual
	Q2 2009 Q2 2010	7	C + SD	−0.80 **a**	−3.34	34.86	Quarterly
		1	C + T + SD	−1.15 **a**	−3.23	16.75	Quarterly

C Constant variables. **SD** Centred seasonal dummy variables. **T** Trend variables. **a** Insignificant at the 95 per cent confidence level.
Note: Unit root tests were undertaken using data as of April 2017.

Long-term contracts and price exogeneity

Domestic timber prices may be exogenous, or unaffected by shifts in demand, in the short run due to long-term contracts between growers and processors. These contracts often specify adjustments to log prices based on changes in variables that are determined outside of the forestry industry. For example, one of the most heavily weighted factors in these adjustment mechanisms are employees' wages, which are typically based on movements in the appropriate award rates, as set down by the Fair Work Commission and its predecessors. These are based on changes in inflation, interest rates, disposable income of households and other macroeconomic variables (Fair Work Commission 2015). This, combined with sawnwood prices appearing to closely follow log prices (Figure A1), suggests structural timber prices may not be affected by shifts in demand for sawnwood products in the short term.

Figure A1 Softwood sawnwood and log price indexes



Note: Domestic MGP10 price based on quarterly data.
Source: ABARES 2018; Indufor 2017

Table A4 Instrumental variables regressions, endogeneity and weak instrument tests

Coefficients and test statistics	Untreated structural pine		Treated structural pine		Aggregate structural pine	
	TS1	TS2	TS3	TS4	TS5	TS6
Price variable coefficients						
Domestic price	–1.28	–1.21	–1.21	–0.95	–1.21 **a**	–1.02 **a**
Import price: aggregate	–	0.09	0.09	–	0.09	0.07
Import price: untreated	–0.02	–	–	–	–	–
Import price: treated	–	–	–	–0.07	–	–
Steel price	–0.05	–0.17	–0.17	–0.35	–0.17	–0.15
Residential construction coefficients						
House commencements	0.64 **a**	0.72 **a**	0.72 **a**	0.77 **a**	0.72 **a**	0.49 **a**
Other commencements	0.09	0.10	0.10	0.10	0.10	0.10
Value of work done on new houses	0.23	0.32	0.32	–	0.32	–
Trend and seasonal terms						
Constant	–0.10 **a**	–0.09 **a**	–0.09 **a**	–0.05 **a**	–0.09 **a**	–0.09 **a**
D1	0.16 **a**	0.17 **a**	0.17 **a**	0.19 **a**	0.17 **a**	0.15 **a**
D2	0.11 **a**	0.09 **a**	0.09 **a**	0.07 **a**	0.09 **a**	0.11 **a**
D3	0.11 **a**	0.10 **a**	0.10 **a**	0.08 **a**	0.10 **a**	0.11 **a**
Weak instrument and endogeneity test						
Cragg-Donald F-stat	14.06 **b**	14.10 **b**	14.10 **b**	12.14 **b**	14.10 **b**	15.06 **b**
Difference in J-stats	3.93 **a**	2.63	2.63	0.68	2.63	1.86

a Coefficient significant at the 95 per cent confidence level. **b** Value between 10 per cent and 15 per cent Stock-Yogo critical values.

Note: Change in domestic price from previous quarter used as only instrument. Models for treated timber demand exclude observations before the March quarter of 2006 and after the December quarter of 2016 due to excessive volatility in volume and prices.

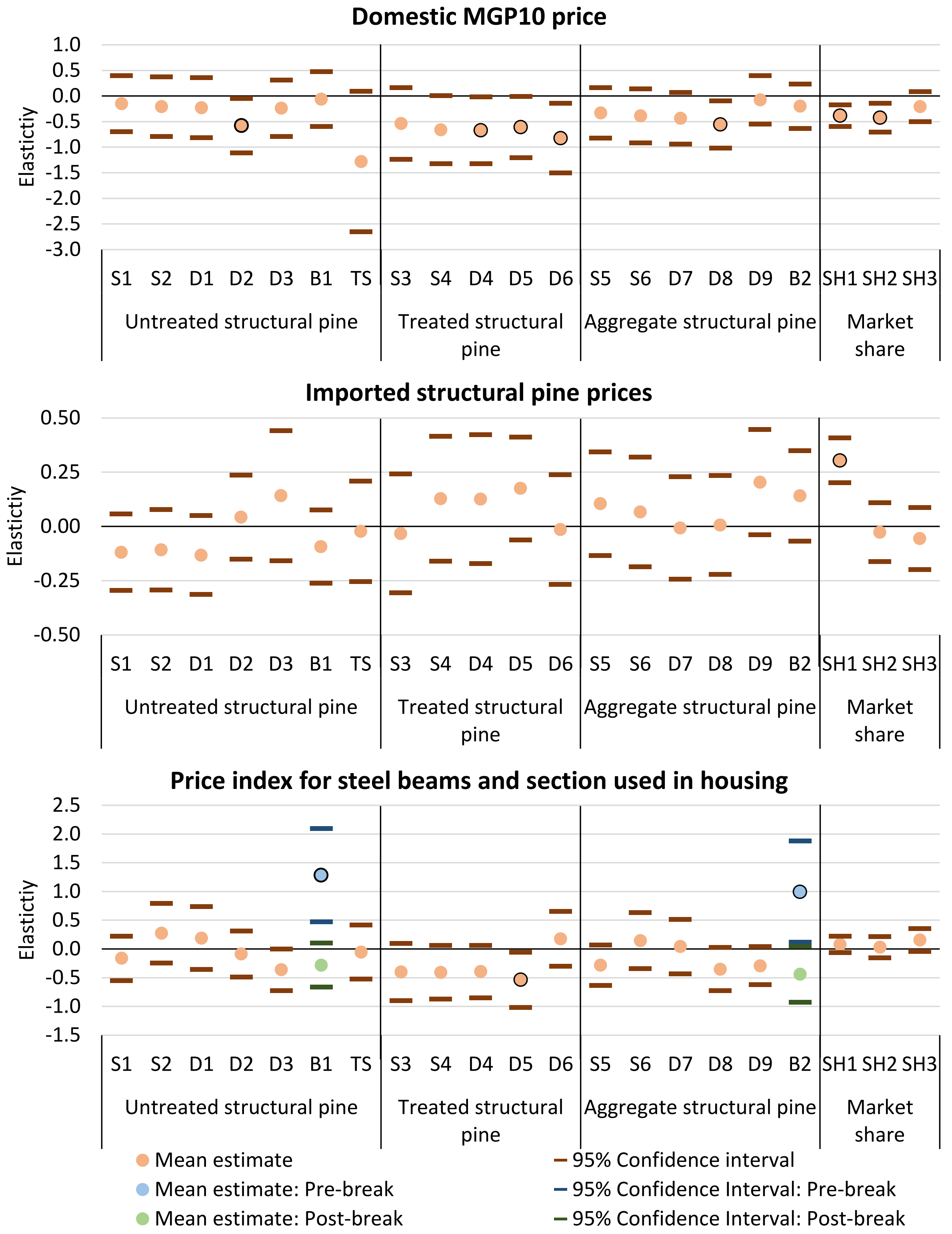
Appendix B: Detailed results

Table B1 Price elasticities of demand for domestically produced structural pine—all models

Variables	Untreated structural pine							Treated structural pine e					Aggregate structural pine						Domestic share		
Model	**S1**	**S2**	**D1**	**D2**	**D3**	**B1 b**	**TS d**	**S3**	**S4**	**D4**	**D5**	**D6**	**S5**	**S6**	**D7**	**D8**	**D9**	**B2 b**	**SH1**	**SH2**	**SH3**
Price variable coefficients																					
Domestic price	−0.23	−0.21	−0.23	–	–	−0.06	−1.28	−0.54	−0.66	−0.67 **a**	–	–	−0.33	−0.39	−0.43	–	–	−0.20	−0.38 **a**	–	–
Import price **c**	0.01	−0.11	−0.13	–	–	−0.01	−0.02	−0.03	0.13	0.13	–	–	0.11	0.07	−0.01	–	–	0.14	0.30 **a**	–	–
Steel price	−0.16	0.27	0.19	–	–	–	−0.05	−0.40	−0.41	−0.39	–	–	−0.28	0.15	0.04	–	–	–	0.08	–	–
Steel price: before	–	–	–	–	–	1.27 **a**	–	–	–	–	–	–	–	–	–	–	–	0.99 **a**	–	–	–
Steel price: after	–	–	–	–	–	−0.16	–	–	–	–	–	–	–	–	–	–	–	−0.44	–	–	–
Price variable coefficients—previous quarter																					
Domestic price	–	–	–	−0.58 **a**	–	–	–	–	–	–	−0.61 **a**	–	–	–	–	−0.55 **a**	–	–	–	−0.42 **a**	–
Import price **c**	–	–	–	0.04	–	–	–	–	–	–	0.18	–	–	–	–	0.01	–	–	–	−0.03	–
Steel price	–	–	–	−0.09	–	–	–	–	–	–	−0.54 **a**	–	–	–	–	−0.35	–	–	–	0.03	–
Price variable coefficients—two quarters prior																					
Domestic price	–	–	–	–	−0.23	–	–	–	–	–	–	−0.82 **a**	–	–	–	–	–	–	–	–	−0.21
Import price **c**	–	–	–	–	0.14	–	–	–	–	–	–	−0.01	–	–	–	–	–	–	–	–	−0.06
Steel price	–	–	–	–	−0.36	–	–	–	–	–	–	0.18	–	–	–	–	–	–	–	–	0.15

a Coefficient significant at the 95 per cent confidence level. **b** Structural break occurs at the September quarter of 2007. **c** Refers to the average import price of all structural pine products for models of aggregate structural pine; the average import price of untreated pine products for models of untreated structural pine; and the average import price of treated structural pine products for models of treated structural pine. **d** Change in domestic price from previous quarter used as only instrument. **e** Models for treated structural pine exclude observations before the March quarter of 2006 and after the December quarter of 2016 due to excessive volatility in volume and prices.
Note: See Table A1 for description of model types. All models include a constant and quarterly dummy variables.

Figure B1 Elasticities of demand and confidence intervals—domestic MGP10 prices



Note: See Table A1 for description of model types. Bolded markers represent coefficient estimates which are statistically significant at the 95 per cent confidence level. Structural break date for B1 and B2 is the September quarter of 2007. Models for treated structural pine exclude observations before the March quarter of 2006 and after the December quarter of 2016 due to excessive volatility.

Table B2 Short-run models of demand for domestically produced untreated structural pine—detailed results

Model	S1	S2	D1 b	D2	D3	B1 c	TS d
Current price variable coefficients							
Domestic price	−0.15	−0.21	−0.23	–	–	−0.06	−1.28
Import price	−0.12	−0.11	−0.13	–	–	−0.010	−0.02
Steel price: whole period	−0.16	0.27	0.19	–	–	–	−0.05
Steel price: before Q3 2007	–	–	–	–	–	1.27 **a**	–
Steel price: during and after Q3 2007	–	–	–	–	–	−0.16	–
Lagged price variable coefficients							
Domestic price: 1 quarter	–	–	–	−0.58 **a**	–	–	–
Import price: 1 quarter	–	–	–	0.04	–	–	–
Steel price: 1 quarter	–	–	–	−0.09	–	–	–
Domestic price: 2 quarters	–	–	–	–	−0.23	–	–
Import price: 2 quarters	–	–	–	–	0.14	–	–
Steel price: 2 quarters	–	–	–	–	−0.36	–	–
Construction variable coefficients							
House commencements	0.60 **a**	0.62 **a**	0.60 **a**	0.50 **a**	0.36 **a**	0.60 **a**	0.64 **a**
Other commencements	0.05	0.07	0.06	0.05	0.04	0.06	0.09
Value of work done on new houses	0.26	0.28	0.31	0.29	0.14	0.20	0.23
Constant and seasonal dummies							
Constant	−0.09 **a**	−0.11 **a**	−0.10 **a**	−0.10 **a**	−0.10 **a**	−0.11 **a**	−0.10 **a**
March quarter	0.14 **a**	0.14 **a**	0.12 **a**	0.12 **a**	0.11 **a**	0.15 **a**	0.16 **a**
June quarter	0.11 **a**	0.12 **a**	0.12 **a**	0.13 **a**	0.14 **a**	0.12 **a**	0.11 **a**
September quarter	0.10 **a**	0.11 **a**	0.14 **a**	0.10 **a**	0.12 **a**	0.11 **a**	0.11 **a**
Lagged dependent variable coefficients							
1 quarter	–	–	−0.01	–	–	–	–
2 quarters	–	–	0.05	–	–	–	–
3 quarters	–	–	0.14	–	–	–	–
4 quarters	–	–	0.07	–	–	–	–
Other coefficients							
Q2 2004 dummy	0.09 **a**	–	–	–	–	–	–
Q3 2008 dummy	–	−0.13 a	−0.14 **a**	−0.08	−0.08	−0.04	–
Q4 2010 dummy	−0.11 **a**	–	−0.11 **a**	−0.11 **a**	−0.13 **a**	–	–
Model fit							
Adjusted R-squared	0.81	0.78	0.81	0.82	0.82	0.82	0.71
F-statistic	21.44 **a**	20.32 **a**	16.04 **a**	22.73 **a**	22.70 **a**	22.70 **a**	16.64 **a**

a Coefficient significant at the 95 per cent confidence level. **b** Coefficients for lags of demand jointly insignificant at the 95 per cent confidence level . **c** Structural break occurs at the September quarter of 2007. **d** Change in domestic price from previous quarter used as only instrument.
Note: See Table A1 for description of model types.

Table B3 Short-run models of demand for domestically produced treated structural pine

Model	S3	S4	D4 b	D5	D6
Current price variable coefficients					
Domestic price	–0.54	–0.66	–0.67 **a**	–	–
Import price	–0.03	0.13	0.13	–	–
Steel price	–0.40	–0.41	–0.39	–	–
Lagged price variable coefficients					
Domestic price: 1 quarter	–	–	–	–0.61 **a**	–
Import price: 1 quarter	–	–	–	0.18	–
Steel price: 1 quarter	–	–	–	–0.54 **a**	–
Domestic price: 2 quarters	–	–	–	–	–0.82 **a**
Import price: 2 quarters	–	–	–	–	–0.01
Steel price: 2 quarters	–	–	–	–	0.18
Construction variable coefficients					
House commencements	0.99 **a**	0.91 **a**	0.81 **a**	0.77 **a**	0.99 **a**
Other commencements	0.08	0.07	0.06	0.02	0.05
Value of work done on new houses	0.33	0.15	–0.00	0.19	0.18
Constant and seasonal dummies					
Constant	–0.05 **a**	–0.05 **a**	–0.07 **a**	–0.04 **a**	–0.06 **a**
March quarter	0.20 **a**	0.19 **a**	0.15 **a**	0.15 **a**	0.19 **a**
June quarter	0.05	0.06 **b**	0.08	0.08 **a**	0.06
September quarter	0.08 **a**	0.08 **a**	0.11 **a**	0.08 **a**	0.08 **a**
Lagged dependent variable coefficients					
1 quarter	–	–	–0.08	–	–
2 quarters	–	–	0.19	–	–
3 quarters	–	–	0.12	–	–
4 quarters	–	–	–0.02	–	–
Other coefficients					
Q4 2010 dummy	–	–	–	–0.11 **a**	–
Q1 2015 dummy	–	0.15 **a**	0.18 a	0.10	0.16 **a**
Model fit					
Adjusted R-squared	0.75	0.79	0.82	0.82	0.78
F-statistic	15.71 **a**	16.87 **a**	14.51 **a**	18.56 **a**	16.34 **a**

a Coefficient significant at the 95 per cent confidence level. **b** Coefficients for lags of demand are jointly insignificant at the 95 per cent confidence level.
Note: See Table A1 for description of model types. Models for treated timber demand exclude observations before the March quarter of 2006 and after the December quarter of 2016 due to excessive volatility in volume and prices.

Table B4 Short-run models of demand for domestically produced aggregate structural pine

Model	S1	S2	D1 b	D2	D3	B1 c
Current price variable coefficients						
Domestic price	–0.33	–0.39	–0.43	–	–	–0.20
Import price	0.11	0.07	–0.01	–	–	0.14
Steel price: whole period	–0.28	0.15	0.04	–	–	–
Steel price: before Q3 2007	–	–	–	–	–	0.99 **a**
Steel price: after Q3 2007	–	–	–	–	–	–0.44
Lagged price variable coefficients						
Domestic price: 1 quarter	–	–	–	–0.55 **a**	–	–
Import price: 1 quarter	–	–	–	0.01	–	–
Steel price: 1 quarter	–	–	–	–0.35	–	–
Domestic price: 2 quarters	–	–	–	–	–0.08	–
Import price: 2 quarters	–	–	–	–	0.20	–
Steel price: 2 quarters	–	–	–	–	–0.29	–
Construction variable coefficients						
House commencements	0.67 **a**	0.68 **a**	0.68 **a**	0.59 **a**	0.48 **a**	0.69 **a**
Other commencements	0.07	0.08	0.06	0.04	0.04	0.06
Value of work done on new houses	0.33 **a**	0.34 **a**	0.37 **a**	0.44 **a**	0.26	0.29
Constant and seasonal dummies						
Constant	–0.08 **a**	–0.09 **a**	–0.08 **a**	–0.07 **a**	–0.08 **a**	–0.10 **a**
March quarter	0.15 **a**	0.16 **a**	0.12 **a**	0.10 **a**	0.12 **a**	0.16 **a**
June quarter	0.09 **a**	0.11 **a**	0.08 **a**	0.10 **a**	0.12 **a**	0.10 **a**
September quarter	0.10 **a**	0.11 **a**	0.13 **a**	0.12 **a**	0.12 **a**	0.10 **a**
Lagged dependent variable coefficients						
1 quarter	–	–	–0.05	–0.18	–	–
2 quarters	–	–	0.03	–	–	–
3 quarters	–	–	0.20	–	–	–
4 quarters	–	–	–0.04	–	–	–
Other coefficients						
Q2 2004 dummy	0.10 **a**	–	–	–	–	–
Q3 2008 dummy	–	–0.12 **a**	–0.12 **a**	–0.09 **a**	–0.09 **a**	–
Q4 2010 dummy	–0.11 **a**	–	–0.12 **a**	–0.13 **a**	–0.14 **a**	–
Q1 2015 dummy	–	–	–	–	–	–
Moving average: 1 quarter	–	–	–	–	–	–0.26
Model fit						
Adjusted R-squared	0.83	0.80	0.84	0.85	0.85	0.84
F-statistic	25.09 **a**	22.46 **a**	19.30 **a**	26.70 **a**	27.00 **a**	24.84 **a**

a Coefficient significant at the 95 per cent confidence level. **b** Coefficients for lags of demand are jointly insignificant at the 95 per cent confidence level. **c** Structural break occurs at the September quarter of 2007.
Note: See Table A1 for description of model types.

Table B5 Short-run models of domestic market share in total consumption

Model	SH1	SH2	SH3
Current price variable coefficients			
Domestic price	–0.38 **a**	–	–
Import price	0.30 **a**	–	–
Steel price	0.08	–	–
Lagged price variable coefficients			
Domestic price: 1 quarter	–	–0.42 **a**	–
Import price: 1 quarter	–	–0.03	–
Steel price: 1 quarter	–	0.03	–
Domestic price: 2 quarters	–	–	–0.21
Import price: 2 quarters	–	–	–0.06
Steel price: 2 quarters	–	–	0.15
Constant and seasonal dummies			
Constant	–0.02 **a**	–0.01 **a**	–0.02 **a**
March quarter	0.03 **a**	0.02 **a**	0.02 **a**
June quarter	0.02 **a**	0.02 **a**	0.02 **a**
September quarter	0.02 **a**	0.02	0.02 **a**
Model fit			
Adjusted R-squared	0.54	0.20	0.13
F-statistic	11.41 **a**	3.20 **a**	2.24 **a**

a Coefficient significant at the 95 per cent confidence level.

References

ABS 2017a, 8752.0 Building activity, Australia, Jun 2017, Australian Bureau of Statistics, Canberra, accessed 11 October 2017.

——2017b, 5465.0 International Trade, Australia - Information Consultancy Subscription Service, Australian Bureau of Statistics, Canberra, accessed 28 July 2017.

——2017c, 6427.0 Producer Price Indexes, Australia, Jun 2017, Australian Bureau of Statistics, Canberra, accessed 28 July 2017.

Adams, M 1977, *Effects of National Forest Timber Harvest on Softwood Stumpage Lumber, and Plywood Markets: An Econometric Analysis*, Forest Research Laboratory School of Forestry, Oregon State University, Oregon.

Adams, DM, Boyd, R & Angle, J 1992, 'Evaluating the Stability of Softwood Lumber Demand Elasticity by End-use Sector: A Stochastic Parameter Approach', *Forest Science*, vol. 38, no. 4, pp. 825–841.

Bai, J 1997, 'Estimating Multiple Breaks One at a Time', *Econometric Theory*, vol. 12, no. 3, pp. 315–352.

Belsley, D, Kuh, E & Welsh, R 1980, *Regression diagnostics: identifying influential data and sources of collinearity*, Wiley series in probability and statistics, John Wiley & Sons, New York, pp. 11–6.

Black, S 2014, *Increasing Deemed to Satisfy Height Limits for Timber Construction*, prepared for Forests and Wood Products Australia by The Centre for International Economics, Canberra.

Bleby, M 2016, National Construction Code change opens way for timber buildings up to 8 storeys, *Financial Review*, accessed 10 October 2017.

Breusch, T 1978, 'Testing for autocorrelation in dynamic linear models', *Australian Economic Papers*, vol. 17, pp. 334–55.

Breusch, T & Pagan, R 1979, 'A simple test for heteroskedasticity and random coefficient variation', *Econometrica*, vol. 47, no. 5, pp. 1287–94.

Bylund, D 2017, *Enabling Prefabricated Timber in Building Systems for Class 2 to 9 Buildings*, prepared for Forests and Wood Products Australia, Melbourne.

Chow, G 1960, 'Tests of equality between sets of coefficients in two linear regressions', *Econometrica*, vol. 28, no. 3, pp. 591–605.

Cunningham, T 2013, *Factors Affecting the Cost of Building Work – An Overview*, Dublin Institute of Technology, Dublin.

Donahue, M 2016, Move Over, Steel: The High Rises of Tomorrow Are 'Plyscrapers', Smithsonian.com, accessed 10 October 2017.

Doran, HE & Williams, DF 1982, *The Demand for Domestically Produced Sawn Timber; An Application of the Diewert Cost Function*, University of New England, Armidale, and Victorian School of Forestry, Creswick.

Fair Work Commission 2015, Annual Wage Review 2014–15, Timber Industry Award 2010, MA000071 PR566749, Melbourne, Accessed 10 October 2017.

FWPA 2018, FWPA softwood data series, Forest and Wood Products Australia, Melbourne.

Gaston, W 1979, An Econometric Analysis of the Demand for Wood products in Japan by Product Type, Species, and Source, B.Sc thesis, The University of British Columbia, M.Sc thesis, The University of Guelph.

Gellner, B, Constantino, L & Percy, M 1990, 'Dynamic adjustments in the United States and Canadian construction industries', *Canadian Journal of Forest Research*, vol. 21, no. 3, pp. 326–332.

Godfrey, L 1978, 'Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables', *Econometrica*, vol. 46, pp. 1293–1301.

Hylleberg, S, Engle, R, Granger, C & Yoo, BS 1990, "Seasonal integration and cointegration', *Journal of Economics*, vol. 44, issue 1–2, pp. 215–238.

Kapambwe, M, Ximenes, F, Vinden, P & Keenan R 2009, *Dynamics of Carbon Stocks in Timber in Australian Residential Housing*, Forest and Wood Products Australia, Melbourne.

Indufor 2017, Timber Market Survey June quarter 2017, Subscription.

Ljung, G & Box, G 1978, 'On a measure of lack of fit in time series models', *Biometrica*, vol. 65, pp. 297–303.

McKillop, W, Stuart, TW & Geissler, PJ 1980, 'Competition Between Wood Products and Substitute Structural Products: An Econometric Analysis', *Forest Science*, vol. 26, no. 1, pp. 134–148.

Mitchell, P & Tucker, S 2011, *Investment Plan for Increasing the Use of Wood Products in Residential Construction*, Forest and Wood Products Australia, Melbourne.

Nagubadi, RV, Zhang, D, Prestemon, JP & Wear, DN 2004, 'Softwood Lumber Products in the United States: Substitutes, Complements, or Unrelated?' *Forest Science*, vol. 50, no. 4, pp. 416–426.

Ramsey, J 1969, 'Tests for specification errors in classical linear least squares regression analysis', *Journal of the Royal Statistical Society*, Series B 31, pp. 350–71.

Robinson, VL 1974, 'An Econometric Model of Softwood Lumber and Stumpage Markets, 1947–1967', *Forest Science*, vol. 20, no. 2, pp. 171–179.

Rockel, M & Buongiorno, J 1982, 'Derived Demand for Wood and Other Inputs in Residential Construction: A Cost Function Approach', *Forest Science*, vol. 28, no. 2, pp. 207–219.

Soria, JA 2005, *Estimating North American Softwood Lumber in Cross-price Elasticities of Demand Using Discrete Choice Consumer Preferences*, M.Sc thesis, College of Natural Resources, University of Idaho.

Spelter, H 1985, 'A Product Diffusion Approach to Modeling Softwood Lumber Demand', *Forest Science*, vol. 31, no. 3, pp. 685–700.

Tollefson, J 2017, The wooden skyscrapers that could help to cool the planet, *International Weekly Journal of Science*, vol. 545, pp. 280–282, doi: 10.1038/545280a, accessed 10 October 2017.

Uri, ND & Boyd, R 1991, 'Factors affecting the demand for softwood lumber in the United States', *Applied Mathematical Modelling*, vol. 15, iss. 6, pp. 295–304.

Waggener, TR, Gerard, FS & Howard, MH 1978, *Elasticities of Demand for Forest Products over Time*, College of Forest Resources, University of Washington, Washington.

White, H 1980, 'A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity', *Econometrica*, vol. 48, pp. 817–38.

World Bank 2017, Population Density (people per sq. km of land area), Washington, DC, accessed 10 October 2017.