AN ANALYSIS OF AUSTRALIA'S SOLID WOOD TIMBER PRODUCTION AND IMPORTS

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Cover image: Probolinggo, East Java / Indonesia - Oct 11 2019
Logging boat and tug boat of logging company located near port harbour

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North East NSW Forestry Hub

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Executive Summary

This report presents analyses of Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and Australian Bureau of Statistics (ABS) solid wood production and trade datasets to better understand Australia's solid wood timber production and imports over the period 1996-97 to 2022-23. This period was characterised by: (a) government policy-driven contraction in native forest timber production; (b) a static softwood plantation estate managed for sawlog for domestic processing; (c) rapid expansion followed by contraction of hardwood plantations managed for woodchip and logs for export; and (d) national population growth of 42%.

A Vector Error Correction Model (VECM) was fitted to Australian solid wood market data for domestic supply, imports, exports and domestic demand. The VECM was used to estimate the cointegrating vector that defines the long-run materials balance of Australia's solid wood market, as well as the adjustment behaviour of market participants to shocks. Australia's trade data was also intersected with the Global Illegal Logging and Associated Trade (ILAT) Risk Data Tool (https://www.forest-trends.org/idat/) published by Forest Trends to identify Australian timber supply chains with elevated-risk exposure.

Preliminary analysis of Australia's import volume revealed the importance of imports from China, which accounted for 30% of Australia's solid wood imports over the period 2018-19 to 2022-23, up from 2% in the period 1996-97 to 2000-01. To improve understanding of Australia's global materials footprint, an analysis of China's solid wood product supply chain was performed with official China government import and export statistics (2018 to 2023) available from General Administration of Customs of the People's Republic of China (http://stats.customs.gov.cn).

Analyses revealed that Australian demand (apparent consumption) for solid wood products fluctuated, but generally remained within the range of about 18 to 20 M m^3 of roundwood equivalent (RWE, i.e. log volume) per annum over the period 2001-02 to 2016-17 (latest period available). In 1996-97, Australia imported 2.9 M m^3 RWE/y of solid wood products, but imports had grown to 7.0 M m^3 RWE/y by 2022-23, suggesting a growing shortfall in domestic supply.

Commencing in 1996-97, implementation of reduced native forest harvest policies progressively reduced domestic hardwood sawlog supply, such that by 2022-23, annual harvest volumes had contracted 75%, from 4.0 M m^3 RWE/y to 1.0 M m^3 RWE/y. Although supplies of softwood plantation sawlog had increased since the mid-1990s, aggregate domestic sawn hardwood and softwood production peaked in 2009-10. By the early 2020s, aggregate domestic hardwood and softwood sawlog harvest volumes were less than in the mid-1990s. Hardwood plantation establishment and the types of harvested products from the estate did not respond to declining domestic sawlog production, with only 1.6% of harvested hardwood plantation log volume over the period 2002-03 to 2023-24 used for domestic manufacture of solid wood products. Since the turn of the century, domestic manufacture of engineered wood products (EWPs) has been at or below the level of

production achieved in the early 2000s. Therefore, EWP manufacture has not expanded in response to falling native forest production.
Clear market differentiation between Australian native forest hardwoods and plantation softwoods was revealed by a review of literature and via the VECM. Literature review revealed native forest hardwoods are demanded for appearance applications (e.g. decking and flooring) and in infrastructure and heavy industrial applications (e.g. wharfs, bridge girders, cross-arms, electricity distribution poles). In contrast, plantation softwoods are mostly demanded for internal framing in residential construction. The VECM analysis confirmed statistically that native forest hardwoods and plantation softwoods are complementary goods consumed together in Australia, not substitutes for one another. Consequently, increased softwood plantation harvest volumes do not mitigate demand for products historically manufactured from Australia's native forest hardwoods.

The VECM analysis also found that reduced domestic native forest harvesting was a structural driver of Australia's growing import dependency, with a long-run timber harvest leakage to imports at the rate of 81.3%. International leakage from reduced native forest production was primarily to imports of builders' carpentry, engineered wood products and wooden furniture. Critically, 86.8% of the wood supplied to meet the displaced demand was found to have been sourced from nations identified by ILAT as having elevated-risk of illegal logging in their supply chains, including hardwoods from Southeast Asia and the Congo Basin. It is challenging for domestic producers to compete against imported product from jurisdictions with lower environmental and labour standards and enforcement regimes than those that apply in Australia. The analysis highlights challenges with timber supply chain traceability.

In 2022-23, Australians consumed twice as much imported elevated-risk timber as was produced from lower-risk domestic public and private native forests. Overall, structural forcing of the timber market through reduced native forest harvesting drove 59% of the growth in imports since the mid-1990s. Domestic supply constraints accounted for the remaining 41% of import growth by failing to keep pace with rising domestic demand driven primarily by population.

Although this study did not attempt to estimate carbon leakage from reduced native forest harvest projects, given the nations from which Australia has been procuring substitute products, 81.3% is likely to represent a conservative proxy carbon leakage rate until comparative embodied carbon estimates are available. These findings demonstrate that reduced native forest harvesting in Australia may have counterproductive consequences for carbon and biodiversity at regional and global scales.

The report concludes with a discussion of the challenges of relying on the free market, import regulations and certified timber to reduce Australia's international forest footprint. Policy recommendations are also made.

Definition of Solid Wood Products

Solid wood products in this report have been defined to include the following wood product categories from ABS (2024a) and ABARES (2024b, 2025c):

- sawlogs and veneer logs (hereafter referred to as sawlogs);
- pulplogs for wood-based panels;
- other logs (for poles, piles, girders, and agricultural and landscape rounds);
- sawn softwood;
- sawn hardwood;
- engineered wood products (EWPs);
- builders' carpentry, flooring, decking, joinery, mouldings, and doors (hereafter referred to as builders' carpentry);
- wooden furniture; and
- 'other' (a category within ABARES 'Miscellaneous' wood products category.

The adopted definition of solid wood explicitly excludes woodchip and all pulplogs not destined for engineered wood product (EWP) manufacture.

All builders' carpentry, wooden furniture and 'other' wood product statistics summarised in this report refer to imported volumes and values only. Australia certainly produces these finished product types, but in this report, these volumes are captured at earlier processing stages such as sawn wood and EWPs.

Import data for Australia's large 'Miscellaneous' wood product category is available in ABARES (2024a) and includes builders' carpentry, flooring, mouldings, doors, and 'other'. The total value of Miscellaneous wood product imports in 2022-23 was $1.73 billion. In 2021-22, Australian imports of 'further processed sawnwood', which broadly aligns with builders' carpentry and related products, accounted for 5.1% of global trade in these products, which ranked Australia third highest by import value after the USA and Germany, and the highest in the world on a per capita basis (UNECE forest products trade flow, https://unece.org/forests/forest-products-trade-flow).

ABARES economists explained that the World Customs Organisation changed the definition of builders' carpentry in 2022, splitting it into further categories of glue-laminated timber (glulam), I-beams, cross-laminated timber (CLT or X-lam), and other EWPs (engineered structural products excluding Glulam, CLT or X-lam and I-beams). ABARES have backdated these changes to 2018. At the time of writing, these products have been shifted into the 'Other' category within 'Miscellaneous' wood products. To remain consistent with previous wood product import reporting by ABARES and research by Venn (2023), these product types have been added back to builders' carpentry in this analysis. Therefore, builders' carpentry analysed in this paper includes ABARES groupings of builders' carpentry, flooring, mouldings, doors and the types of EWPs (recorded in 'other'), as specified above.

The 'other' solid wood product category includes wooden tableware and kitchenware, wooden statuettes and ornaments, wooden frames (e.g. for paintings and photographs), wood marquetry and inlaid wood, wooden caskets, cases, boxes and crates, wooden coffins, coopers' products, wooden tools and tool handles, wooden clothes hangers, and wooden shuttering for concrete construction work.

ABARES ceased reporting secondary wood products, including wood furniture, in their Australian Forest and Wood Products publications and datasets in May 2020 (data available to 2018-19). The wood furniture imports included in this assessment can be found in ABS (2024a) and are limited to the following 10-digit Harmonised Tariff Item Statistical Codes (HTISC) to be consistent with historic ABARES reporting of wood furniture imports and previous analysis by Venn (2023). The total value of wooden furniture imports in 2022-23 was $2.50 billion. In 2021-22, Australian wood furniture imports ranked Australia ninth in the world by wood furniture import value, and accounted for 2.5% of global trade (UNECE forest products trade flow, https://unece.org/forests/forest-products-trade-flow).

- 9401610006 - Seats (excl. swivel seats with height adjustment and seats that convert into beds), with wooden frames, upholstered
- 9401690007 - Seats (excl. swivel seats with height adjustment and seats that convert into beds), with wooden frames (excl. upholstered)
- 9403300041 - Wooden furniture of a kind used in offices
- 9403400024 - Wooden furniture, of a kind used in the kitchen
- 9403500023 - Wooden bedroom furniture
- 9403600025 - Wooden outdoor furniture
- 9403600026 - Wooden coffee tables, nests of tables and similar wooden furniture
- 9403600027 - Wooden buffets, sideboards, wall units and similar wooden furniture
- 9403600028 - Wooden dining tables (excl. kitchen tables)
- 9403600029 - Wooden tables (excl. kitchen, dining and coffee tables or nests of tables and similar wooden furniture)
- 9403600042 - Wooden furniture (excl of a kind used in offices, kitchens, bedrooms & outdoor furniture, coffee/dining/nests of tables, buffets, sideboards, wall units)

Definition of Elevated Risk Imported Timber

This research has adopted the timber harvest or trade illegality framework produced by Forest Trends' Global Illegal Logging and Associated Trade (ILAT) Risk Data Tool (https://www.forest-trends.org/idat/), one of a series of tools designed to facilitate the very initial stages of a national risk assessment when sourcing timber products. Forest Trends is a non-profit organisation funded by government and multilateral agencies (e.g. The World Bank Group and UK Department for International Development), philanthropic foundations (e.g. MacArthur Foundation and Rockefeller Brothers Fund), and corporate and financial institutions (e.g. Business and Biodiversity Offsets Program and Katoomba Group).

ILAT provides an indication of relative national-level risk based on existing indices of corruption, governance, political, timber harvest, conflict and illegal forest product export risk associated with timber trading countries. Illegality risk profile categorisations are lower risk, medium risk and higher risk. To streamline the analysis of international supply chain vulnerability, nations designated as 'medium risk' and 'higher risk' by Forest Trends were aggregated into a single 'elevated-risk' category in this report. This synthesis is justified by the operational logic of timber due diligence; as Forest Trends notes that national-level metrics above lower risk raises flags on the risk of illegal timber entering a supply chain due to underlying political governance and corruption vulnerabilities. Because any country outside the lowest risk tier triggers a non-negligible exposure, treating them as a unified band of elevated risk isolates supply chains that cannot be cleared via basic look-up verifications.

Recommendations and Key Findings

Recommendations

The summary of Australia's solid wood production and imports from the mid-1990s to the early 2020s revealed declining potential sovereign capacity and rapidly rising imports that have been primarily (> 80%) sourced from nations with elevated-risk ILAT profiles. Analysis of Australia's solid wood market with a Vector Error Correction Model statistically identified reduced domestic native forest harvesting as a primary structural driver of Australia's growing import dependency.

Reducing Australia's demand for solid wood products from elevated-risk countries will improve Australia's contribution to global efforts to mitigate the climate and extinction crises. However, as discussed in this report, this is unlikely to be achieved via free-market international trade in timber, due diligence import regulations or by allowing only certified timber imports. In this context, the authors make the following recommendations.

1. Increase funding to the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) to improve importer compliance with the intent of the Illegal Logging Prohibition Act 2012. Funding sources should include levies on wood product importers and be used to build a global genetic and chemical reference library and a rapid forensic testing system.
2. Socio-economically evaluate additional trade interventions (e.g. environmental tariff) to account for legal timber imports that are associated with forest management practices that are not permitted in Australia's highly regulated forestry sector, such as land clearing for timber plantation expansion. These would raise costs in Australia's construction sector, but higher domestic timber prices would also encourage expansion of sovereign capacity. Tariff revenues could be invested in projects to support expansion of sovereign timber capacity.
3. Implement mandatory country of origin labelling for all wood products at wholesale and retail.
4. Improve guidelines for interpreting outputs from the National Carbon Accounting System (NCAS) and Australia's model to track emissions and removals from the land use, land use change and forestry sector, FullCAM, to reduce the risk that they inform the design of perverse forest, carbon and biodiversity conservation policy. For example, because these models are not lifecycle analysis models, they cannot be used to estimate the true atmospheric impact of reduced native forest harvesting.
5. Adopt carbon credit accounting principles that reflect the true atmospheric impact of domestic policy shifts. The international timber harvest leakage rate estimated in this report, 81%, represents a conservative proxy carbon credit discount for reduced native forest harvest projects until comparative embodied carbon estimates are available. Embodied carbon estimates will likely reveal Australia's carbon leakage is higher than its timber harvest leakage.

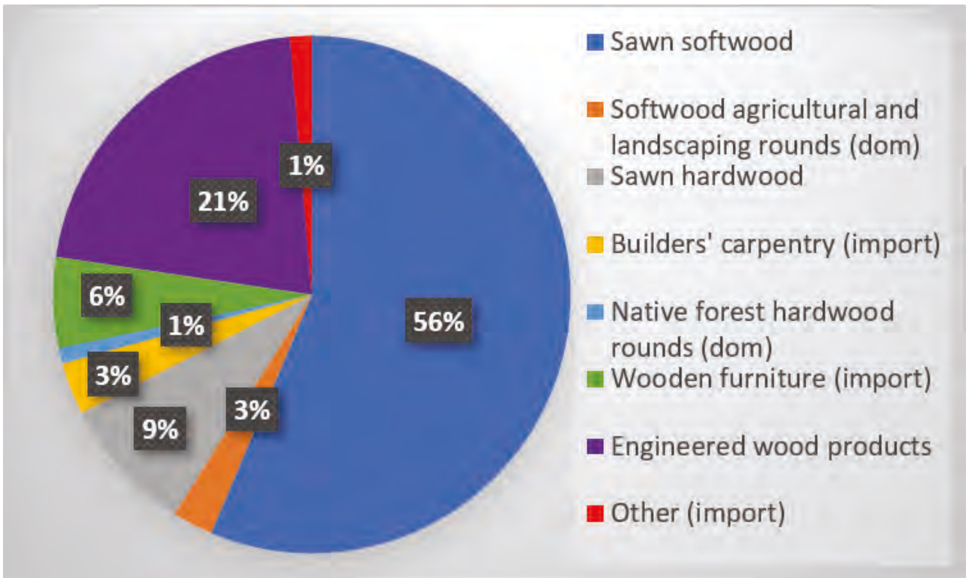
6. Develop evidence-based carbon credit methods that permit sustainable timber production in native forests to incentivise expansion of native forest cover in agricultural landscapes and sustainable native forest timber production.
7. Require domestic reduced native forest harvest projects to account for their impact on net global biodiversity conservation efforts, such as achievement of Kunming-Montreal biodiversity targets. Further research could improve and expand the preliminary sovereign timber capacity – biodiversity conservation trade-off framework presented in this report and develop metrics that enable comparison with domestic impacts.
8. Provide harvest security on public and private land. Avoided State Forest shutdowns will produce immediate sovereign timber capacity and avoided international forest impact benefits. Harvest security on private land will increase the market value of some forest land, provide incentives to retain forests in regions where they are periodically re-cleared for grazing and encourage improved management of private native forest. Resource security will incentivise investment in domestic hardwood product manufacture.
9. Support silvicultural investments to increase domestic sustainable hardwood timber supply from public and private native forests. For example, at a fraction of the per hectare cost of plantation establishment, improved native forest management within the selectively harvested forests of northern New South Wales and southern Queensland can increase timber production by a factor of three to four relative to unmanaged stands. Native forest silviculture can improve Australia's sovereign timber capacity in the medium term (10 to 20 years).
10. Support efforts to improve solid wood product recovery from the existing hardwood plantation estate, which has been planted with species better suited to pulp and paper production. This could include research and development, as well as financial contributions to investments in plant and equipment for the manufacture of engineered wood products. This can improve Australia's sovereign timber capacity in the medium term (5 to 10 years).
11. Encourage expansion of hardwood plantations and silvopastoral systems (which have a lower tree density to facilitate livestock grazing) for solid wood production to add to native forest hardwood supply. This will improve Australia's sovereign timber capacity in the long-term (30+ years).

Key Findings

Timber demand in Australia

- Throughout the period 2001-02 to 2022-23, solid wood timber demand in Australia (apparent consumption) has fluctuated, but generally been between about 18 and 20 M m^3 of roundwood equivalent (RWE, i.e. log volume) per annum.
- Figure 1 provides an estimate of the proportionate breakdown of demand (apparent consumption) in RWE into product categories for the period 2018-19 to 2022-23. Sawn softwood, sawn hardwood and engineered wood products are a mix of domestic production and imports. Remaining product categories are either imported (import) or domestically produced (dom), as indicated.

Figure 1. Proportion of Australian solid wood apparent consumption (in roundwood equivalent volume) by product category, 2018-19 to 2022-23



Sources: ABS (2024a) and ABARES (2024b, 2025c).

- Most demand for sawn softwood, engineered wood products (EWPs), sawn hardwood, wooden furniture and builders' carpentry and 'other' was associated with construction, refurbishment and furnishing of residential and commercial buildings and their surrounds (e.g. fencing and sawn landscaping).
- Strong market differentiation between hardwoods and softwoods in Australia is evident from 2021-22 mill-gate prices for sawn hardwood averaging \$1259/m^3, while the mill-gate price of sawn softwood averaged \$604/m^3.
- A much greater proportion of domestic native forest hardwood is used in appearance applications (25%, e.g. flooring, decking, mouldings, joinery and furniture) than softwood plantation timber (7%).

- Sawn structural timbers and rounds are important markets for domestic hardwoods (26% and 21% of production, respectively) and softwoods (44% and 10%, respectively). However, sawn structural hardwood and hardwood rounds are demanded in outdoor infrastructure and heavy industrial markets (e.g. wharfs, bridge girders, cross-arms, electricity distribution poles, mining timbers, railway sleepers and boardwalks) that sawn and round plantation softwoods do not service.

Domestic timber supply in Australia

- In the early 2020s, domestic supply of solid wood (sawn wood and EWPs) was about 12.3 M m^3 RWE/y.
- This was produced from Australia's forest estate, which consisted of 131.5 M ha of native forests, 1 M ha of softwood plantation and 0.7 M ha of hardwood plantation.
- In 1996, the net harvestable native forest area on Crown land was 10.2 M ha. In 2024, following decades of incremental public forest closures and then the 2024 shutdown of all remaining multiple use public native forests in Western Australia and Victoria, the net area was 2.8 M ha or 2.1% of Australia's native forests.
- Private native forest (PNF) on freehold and leasehold land account for 89.6 M ha (68%) of the national total, of which 21.4 M ha is potentially available and suitable for timber production. However, 85% of that area has very low productivity in its current condition and there are no records about how much PNF is managed by landholders for timber production.
- Softwood plantation area has been static since 2001, meaning this resource has limited capacity to expand solid wood production.
- Hardwood plantation area grew rapidly from the mid-1990s, but has been contracting since the early 2010s. Development of processing technologies may facilitate increased utilisation of Australia's hardwood plantations for domestic solid wood production in the future, including in EWPs. However, over the period 2002-03 to 2023-24, only 1.6% of hardwood plantation log volume was sawn or otherwise likely utilised domestically in solid wood applications.
- The combination of Australian forest policy and private sector investment decisions has ultimately resulted in aggregate native forest and softwood plantation sawlog production levels in the early 2020s being comparable to aggregate production in the mid-1990s. Given population has grown 42% over this period, domestic sawlog production per capita has contracted substantially.
- Domestic EWP production declined from the early 2000s to 2016-17 when ABARES stopped reporting EWP production levels annually. In 2021-22, EWP production was estimated at 2 M m^3 of product – the same level as in 2002-03. Consequently, EWP manufacture has not increased over the past two decades and has decreased on a per capita basis.

Australia's potential sovereign capacity in solid wood products 2001-02 to 2022-23

- Potential sovereign capacity in sawn softwood has been high - 85% to 95%.
- Potential sovereign capacity in EWPs has been falling and reached 77% in 2016-17 (most recent data available). Given rapid growth in EWP imports since then, potential sovereign capacity in EWPs may have decreased further.
- Potential sovereign capacity in sawn hardwood, builders' carpentry and wood furniture contracted dramatically from 68% in 2000-01 to 22% in 2022-23.

Australia's solid wood imports

- Import volume in 2022-23, 7.0 M m^3 RWE, was 138% higher than the level in 1996-97.
- High import volumes are consistent with estimated demand (apparent consumption) at 18 to 20 M m^3 RWE/y and domestic supply at 12.3 M m^3 RWE/y, as described above.
- Imported solid wood accounted for about 35% of all solid wood traded in Australia in the early 2020s.
- In contrast, imports accounted for only 24% of traded wood in Australia in the mid-1990s. Thus, Australia's import dependency has increased by 46% since the mid-1990s.
- Since 2000-01, Australia's imports of sawn softwood have increased by 0.13 M m^3 RWE/y, while the aggregate level of all other solid wood product imports (AMESS; including (sawn hardwood, builders' carpentry, engineered wood products, wood furniture and other) have increased by 2.51 M m^3 RWE/y.
- Since 2000-01, 81.8% of the increase in sawn softwood imports were supplied from nations with elevated ILAT risk profiles, principally Russia and Romania. From 2022, sanctions were placed on Australia's bilateral timber trade with Russia. However, there is risk that Australia continues to consume Russian timber via trade with China.
- Since 2000-01, 86.8% of the increase in all solid wood imports except sawn softwood (AMESS) were supplied by nations with elevated risk profiles, including China and Southeast Asian nations.
- In the early 2020s, China was Australia's largest international supplier of solid wood products, accounting for 30% of imported RWE volume.
- An analysis of China's supply chains indicated that it imports large volumes of hardwood timber from the Congo Basin in Africa, Southeast Asia, Papua New Guinea and the Solomon Islands. The provenance of timber is not tracked as it moves through processors in China. Estimates of Australia's consumption of elevated-risk timber via trade with China have been made.
- Australia's annual forest harvest footprint in elevated-risk countries was estimated at 42,000 ha per annum for the period 2018-19 to 2022-23.

- Over the period 2018-19 to 2022-23, Australians consumed twice as much imported wood from these elevated-risk supply chains annually (1.95 M m^3 RWE/y) as was produced from lower-risk domestic public and private native forests in 2022-23.
- Figure 2 illustrates Australia's mean annual international solid wood imports from countries with elevated-risk profiles.

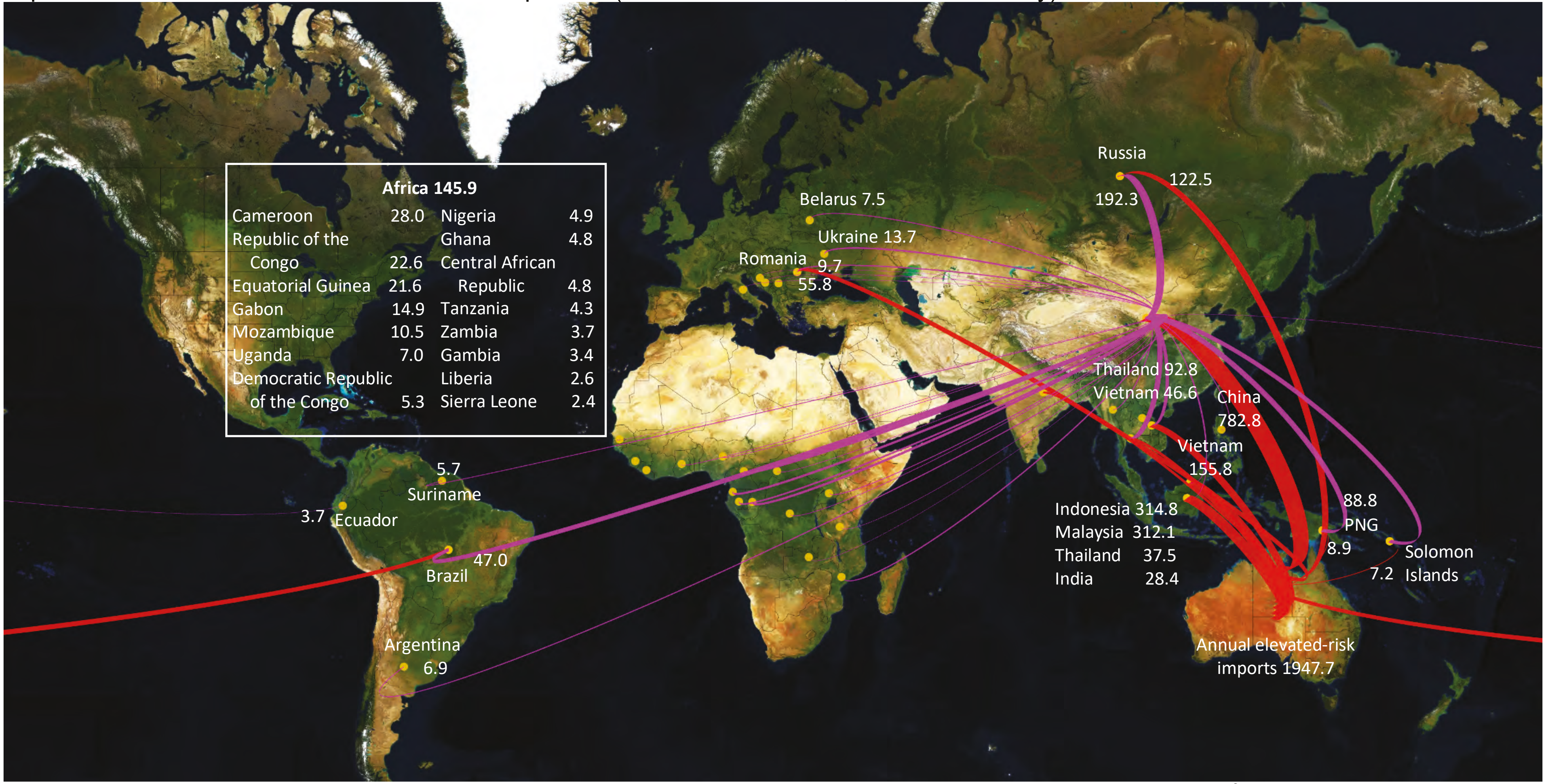
Australia's solid wood exports

- The aggregate annual volume of Australia's solid wood exports varied substantially over the period 2002-03 to 2024-25 between 2 M m^3 RWE/y and 5 M m^3 RWE/y with no trend.
- 59% of all solid wood exports throughout this period were unprocessed softwood and hardwood plantation logs that were not classified as pulp logs.
- This export assessment excluded Australia's main wood product exports, woodchips and pulp logs, because they are not destined for solid wood products.

Australia's timber trade deficit

- The average value of Australia's solid wood imports in real (inflation adjusted to 2022) Australian dollars for the period 2002-03 to 2022-23 was $899/$m^3$ RWE.
- The average value of Australia's solid wood exports in real (inflation adjusted to 2022) Australian dollars for the period 2002-03 to 2022-23 was $160/$m^3$ RWE.
- In 2022-23, Australia's trade deficit in solid wood products was $5.7 billion. This is higher than ABARES reports because of inclusion of wood furniture and a greater fraction of miscellaneous wood imports.
- Australia's trade deficit in paper, pulp and woodchip (not the focus of this study) was $1.4 billion in 2022-23.
- Therefore, Australia's total trade deficit in forest and wood products was $7.1 billion in 2022-23.

Figure 2. Australia's mean annual bilateral demand (red arcs) and multilateral derived demand via China (purple arcs) for solid wood imports from countries with elevated-risk ILAT profiles (2018-19 to 2022-23, 1000s m^3 RWE/y)



Note: Mapped trade flows commencing at a yellow circle were limited to nations from which Australia directly or indirectly procured at least 2000 m^3 RWE/y (2018-19 to 2022-23). The magnitude of selected trade flows have been labelled. PNG is Papua New Guinea. The sum of the purple arcs is equal to the 782,800 m^3 RWE/y imported to Australia from China. From 2022, sanctions were placed on Australia's bilateral timber trade with Russia. Trade flow arcs were visualised with the open-source geospatial analysis tool, Kepler.gl (https://kepler.gl/demo) with a square root scale factor (i.e. 250,000 m^3 RWE/y is five times thicker than 10,000 m^3 RWE/y).

Australia’s timber harvest leakage from reduced native forest harvesting

- A Vector Error Correction Model (VECM) found that timber imports function as a necessary adjustment mechanism to reconcile structural domestic supply deficits. The VECM statistically supports the hypothesis that fluctuations in domestic native forest and softwood plantation sawlog supply have not been driven by the timber market. In the case of the native forest hardwood market, the model found policy-driven reductions in domestic supply has forced compensatory adjustments in timber imports (increases) and construction activity (decreases) to restore the long-run materials balance. This policy causal mechanism is not confounded by baseline macroeconomic drift, as such trends are explicitly accounted for in the model. Furthermore, omitted variable bias tests found no statistical support for the hypothesis that international market factors (e.g. low costs of production in China) are primary drivers of reduced domestic native forest timber production and increased timber imports.
- The VECM found that, over the period 1996-97 to 2022-23, native forest hardwoods and plantation softwoods were complementary goods (consumed together), not substitutes.
- The VECM revealed reduced native forest harvesting was a structural driver of Australia’s growing import dependency, with a timber harvest leakage to imports at the rate of 81.3%. That is, for every 100,000 m^3 RWE decline in native forest timber production, solid wood imports increased by 81,300 m^3 RWE in the long run.
- Structural forcing of the timber market caused by reduced native forest harvesting drove 59% of the growth in Australia’s import volumes since the mid-1990s. Domestic supply constraints accounted for the remaining 41% of import growth by failing to keep pace with rising domestic demand.
- Since 2000-01, 81.8% and 86.8% of Australia’s increase in sawn softwood and all other solid wood imports, respectively, were from elevated-risk jurisdictions, where poor harvesting practices and illegal and planned land clearing for industrial plantation establishment are common.
- The 81.3% timber harvest leakage rate is proposed as a conservative proxy carbon credit discount rate for Australian reduced native forest harvest projects.
- A framework to estimate biodiversity conservation leakage from reduced Australian native forest harvest projects was illustrated with an orangutan example. This suggested Australian consumption of Indonesian and Malaysian timber drives the loss of about 26 orangutans per annum.
- Net global climate and biodiversity conservation benefits of Australia’s reduced native forest harvest policies are likely to be negligible or negative.

Australia cannot rely on the free market, import regulations or certified wood to reduce its international forest footprint

- Australia's relatively high cost of timber production can be largely explained by the cost of regulatory compliance with property rights, environmental and labour laws.
- International timber suppliers in Southeast Asia, Papua New Guinea, the Solomon Islands, Russia and the Congo Basin often benefit from low costs of production precisely because they operate in jurisdictions with fewer environmental and labour constraints.
- If resolution of Australia's domestic timber supply deficit is left to the free market, Australia's dependence on low-cost, high-risk timber imports will likely continue to increase.
- The reality of international timber supply chains is that fraudulent activities have and can lead to illegal timber, as well as timber associated with legal deforestation, native forest clearing for industrial plantation establishment and forest degradation, being marketed in Australia, even though importers fully meet their due diligence requirements under the Illegal Logging Prohibition Act 2012.
- Finite global supply of certified timber means that any increase in Australia's demand for certified imports will add to aggregate international demand, drive increases in consumption of uncertified and illegal wood (as displaced consumers of certified wood seek substitutes) and negatively impact global efforts to reduce carbon emissions and conserve biodiversity.

1. Introduction

Australia has a small population while being the seventh most forested nation in the world (FAO, 2025), which provides the country with an opportunity to produce renewable, climate-friendly wood products, while also conserving forest biodiversity at home and abroad (e.g. by avoiding the offshoring of Australian consumer demand). Solid wood timber production from native forests and softwood plantations has been and remains dominated by supply from public land in Australia. Therefore, government policy has a major impact on how much timber is produced. The economic rationale for public sector forestry in Australia and many other nations during the 19th and 20th centuries was that timber could not be sustainably supplied by the private sector due to low rates of return and long payback periods (Carron, 1985; Dargavel, 1995; Loomis, 2002). This economic logic appears to still apply in Australia today. Although some states have corporatised or sold their softwood plantations to international companies, Australia's total softwood plantation footprint remains stubbornly close to the area established by state forestry agencies by the mid-1990s (ABARES, 2024c).

Private sector forestry expansion in Australia since the mid-1990s was facilitated by indirect federal government investment (de Fegely et al., 2011; Burns et al., 2015) that was channelled into the establishment of short-rotation hardwood plantations primarily for the export woodchip market, rather than long-rotation plantings for domestic solid wood production (Downham et al., 2019; Legg et al., 2021). With the removal of tax incentives and less attractive global markets for woodchips, the hardwood plantation estate area has contracted by more than 30% since 2010 (ABARES, 2025c).

Between 1996 and 2024, the net area of State Forest available for timber production was progressively reduced by 75%, resulting in a decline in national hardwood sawlog production of 75% (3.0 M m^3 roundwood equivalent per year reduction) (National Forest Inventory, 1998; ABARES, 2024b; Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2024). This dramatic contraction coincided with a period of national population growth of 42%, a static area of long-rotation softwood plantations and minimal establishment of hardwood plantations for solid wood production. Australia's plantation estate has limited capacity to increase solid wood production over the next two to three decades to make up for declining native forest production and rising consumer demand.

Until recently the implications of declining sovereign capacity in wood products have been given relatively little attention. Unsurprisingly, Australia's annual solid wood import volumes have increased substantially, from 2.9 M m^3 roundwood equivalent (RWE) in 1996-97 to 7.0 M m^3 RWE in 2022-23. This study was commissioned to raise awareness and understanding of the relationship between domestic supply and Australia's increasing reliance on imported timber, including the negative global climate and biodiversity conservation impacts of Australia's declining sovereign timber capacity. The findings have important implications for Australian forest policy.

Chapters 2 and 3 present data summarising domestic solid wood product demand and supply. Chapter 4 uses that data to estimate potential sovereign capacity in solid wood products. Australia’s rapidly increasing reliance on timber imports is quantified in Chapter 5. This chapter also includes an assessment of the illegality risk of Australia’s imports and an assessment of China’s supply chains, because China accounted for 30% of Australia’s solid wood imports over the period 2018-19 to 2022-23. Chapter 6 reports an econometric analysis of Australia’s growing import reliance. This revealed reduced native forest timber production is a structural driver of imports, with an international timber harvest leakage rate of 81.3%. The challenges of relying on the free market, import regulations and certified wood to address Australia’s growing international forest footprint are discussed in Chapter 7. Chapter 8 outlines policy implications and concludes.

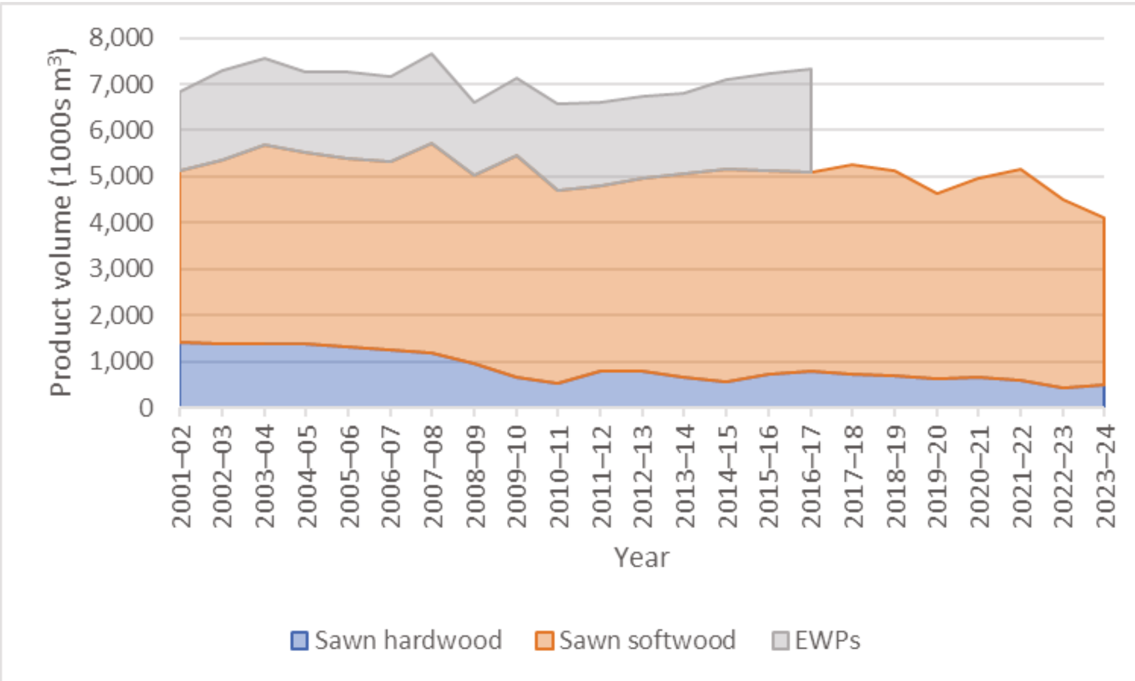
2. Timber Demand in Australia

This chapter quantifies the volume of timber demanded in Australia and broadly describes the markets served by timber. Evidence of market differentiation between hardwoods and softwoods is provided.

2.1 Apparent National Solid Wood Consumption

ABARES (2025c) reported apparent national consumption of sawn hardwood, sawn softwood and engineered wood products (EWPs), defined as domestic production plus imports minus exports. These volumes are illustrated in cubic metres of product volume in Figure 2.1. Apparent consumption of EWPs is presently only available until 2016-17. Assuming EWP consumption has not decreased (unlikely given rising imports, see Chapter 5), apparent consumption of these product categories in the early 2020s is likely to be between 6.5 and 7.5 M m^3/y of product volume.

Figure 2.1. Apparent consumption of sawn hardwood, sawn softwood and engineered wood products in Australia, 2001-02 to 2023-24 in 1000s m^3 of product volume



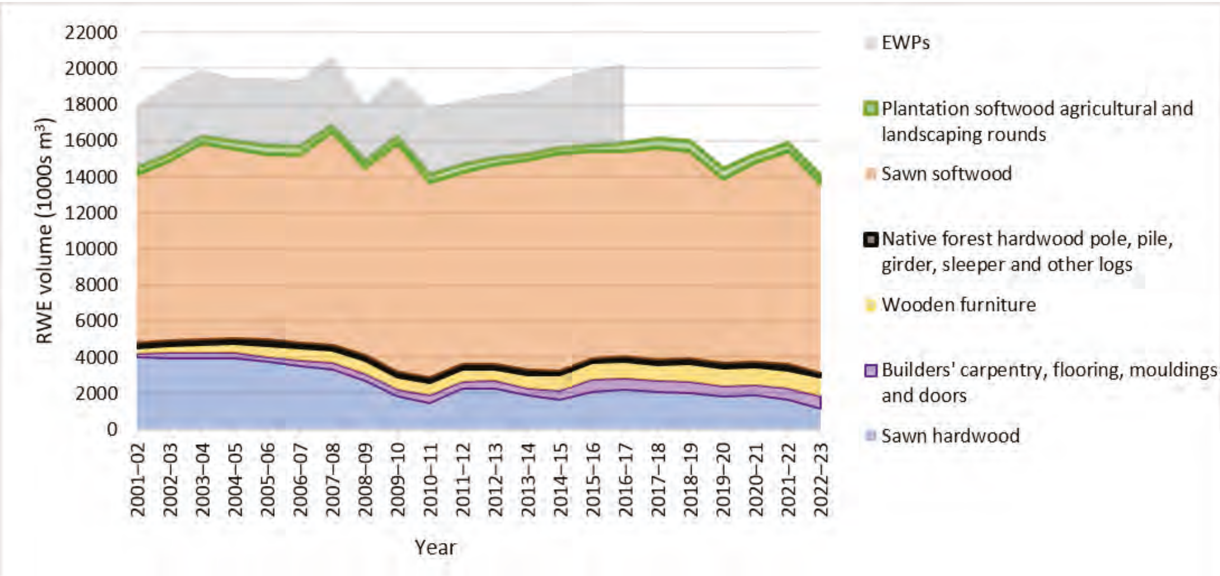
Source: ABARES (2025c)

However, the ABARES (2025c) apparent consumption estimates in Figure 2.1 do not account for major miscellaneous timber import categories, such as builders' carpentry (including wood flooring and decking), mouldings, joinery, doors, frames, wood furniture, and 'other'. This is likely because these imports are typically recorded in dollars rather than wood volume. ABARES apparent consumption estimates also do not account for the demand for roundwood hardwood products, including electricity distribution poles, piles (e.g. for wharfs) and bridge girders. Nor do they account for plantation softwood rounds for agricultural (e.g. vineyards) and landscaping applications (including playgrounds).

Figure 2.2 illustrates a preliminary attempt to provide a more complete estimate of annual total wood consumption in Australia (domestic production plus net imports, less exports). The y-axis units are 1000s m^3 of roundwood equivalent (RWE) or log volume. This unit change relative to Figure 2.1 provides a consistent materials footprint metric for different types of wood products. Methods for conversion of finished product volumes or product values into RWE volume are presented in Appendix A.1.3.

The apparent consumption volumes for sawn hardwood, sawn softwood and EWPs in Figure 2.1 were converted to RWE. To avoid double-counting RWE volume, softwood plantation sawmill residues used in domestic EWP manufacture were subtracted from sawn softwood RWE (as these residues are captured in EWP RWE volume) [1]. RWE estimates of miscellaneous wood products, including builders' carpentry, and wood furniture imports were added to the apparent consumption RWE estimates derived from Figure 2.1. Australia does not export appreciable volumes of these product types, such that imports effectively represent net imports. Finally, estimates of the consumption of hardwood and softwood rounds were added. A recovery rate of 80% from log volume was assumed for rounds (Wong et al., 2024).

Figure 2.2. More complete estimate of Australian apparent consumption of solid wood products, 2001-02 to 2023-24 in 1000s m^3 of RWE volume

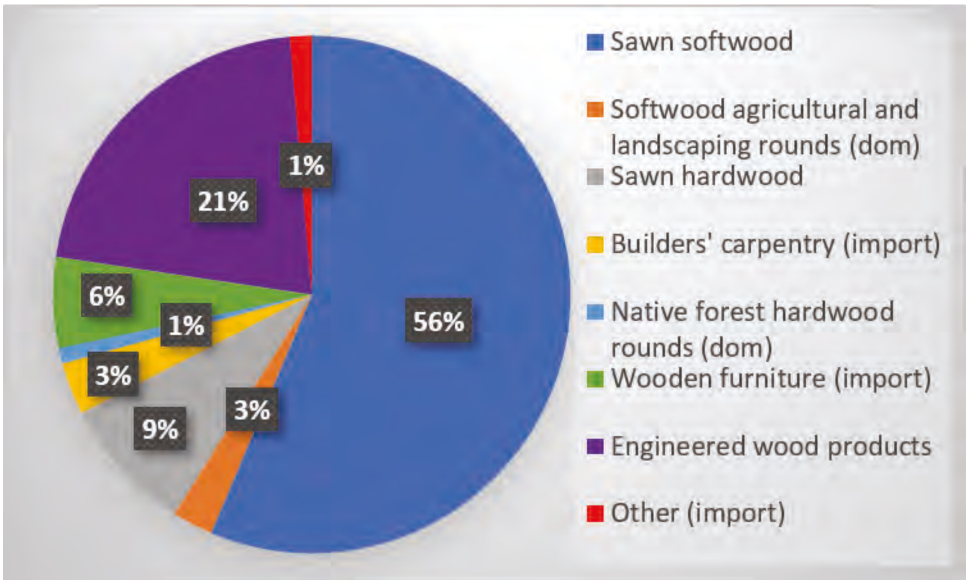


Notes: RWE volume calculation methods are described in Appendix A.1.3.
Sources: ABS (2024a) and ABARES (2024b, 2025c).

[1] Plywood in Australia is largely produced from sawlogs. Australia's particleboard and medium density fibreboard is almost exclusively produced from softwood plantation wood-based panels logs and softwood sawmill residues. The ABARES ABARES, 2025c. Australian forest and wood products statistics, Production and Trade to 2023-24. ABARES series report, Canberra, DOI:https://doi.org/10.25814/z39k-nj30. CC BY 4.0. estimate of wood-based panel log volume was subtracted

As described in Chapter 5, EWP imports have been rising rapidly in recent years (e.g. 1.5 M m^3 RWE in 2016-17 and 2.0 M m^3 RWE in 2022-23), suggesting annual consumption of EWPs is likely to be at least the 4 M m^3 RWE level estimated for 2016-17. Therefore, apparent consumption of solid wood products in Australia in the early 2020s has likely required the harvest of between about 18 to 20 M m^3 RWE/y. Figure 2.3 provides an estimate of the proportionate breakdown of apparent consumption for the period 2018-19 to 2022-23.

Figure 2.3. Proportion of Australian solid wood apparent consumption by product category in roundwood equivalent, 2018-19 to 2022-23



Notes: a. Sawn softwood, sawn hardwood and engineered wood products are from ABARES estimate of apparent consumption in Figure 2.1. It has been assumed that apparent consumption of EWPs in the early 2020s is 4 M m^3 RWE/y, the same level as the most recent ABARES estimate in 2016-17.

b. Builders' carpentry, wooden furniture and 'other' products manufactured domestically are captured within source product category pools such as sawn hardwood. Illustrated proportions of builders' carpentry, wooden furniture and 'other' are imported volumes only. Exported volumes of these products from Australia are negligible.

c. Softwood agricultural and landscaping rounds, and native forest (hardwood) infrastructure rounds are domestically sourced only. Imported volumes are negligible.

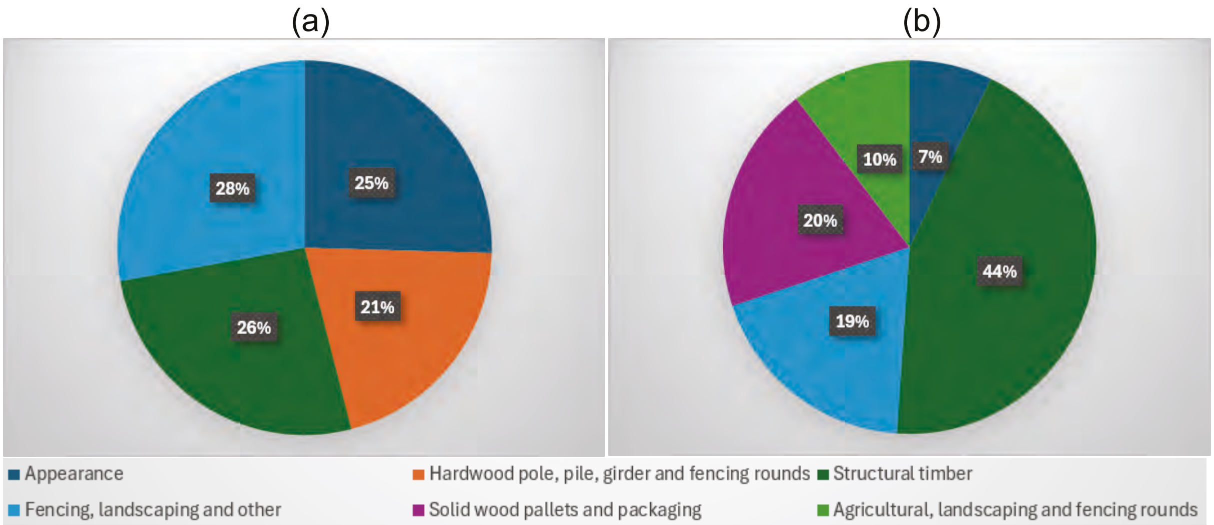
Sources: ABS (2024a) and ABARES (2024b, 2025c).

2.2 The Markets Served by Timber in Australia

Precise statistics about the national allocation of timber to different applications is challenging because available metrics reference outputs from domestic producers, and do not fully capture the application of imported wood. The average aggregate composition of Australian sawmills and post and pole mills in the hardwood and softwood sectors are summarised in Figure 2.4. These summaries include roundwood products; hence, further calculations are required if the proportionate distribution of sawn wood recovered in different sawn product categories is required. Log volumes allocated to roundwood products in Australia are relatively small. However, average green-off-saw recoveries at Australia's hardwood and softwood sawmills are 39% and 47%, respectively, compared to a recovery from log volume of about 80% for roundwood products (Wong et al., 2024). Consequently, the proportion of roundwood product output in average mill output is relatively high.

The hardness, durability in exposed conditions and high aesthetic qualities of Australian native forest hardwoods means they are often put to different uses than plantation pine. Figure 2.4 highlights that a much greater proportion of hardwood mill output goes to residential sawn appearance applications (25%, e.g. flooring, decking, mouldings, joinery and furniture) than for sawn softwood (7%). Structural timbers provide important product lines for hardwoods (26% of production) and softwoods (44%). The main market for domestic (and imported) sawn structural softwood is internal framing for residential construction (Wong et al., 2024; ABARES, 2025a). Dunn (2011) found that native forest sawn structural hardwood and hardwood rounds were important for outdoor infrastructure and heavy industrial markets (e.g. wharfs, bridge girders, cross-arms, electricity distribution poles, mining timbers, railway sleepers and boardwalks) that plantation softwoods cannot service.

Figure 2.4. Composition of products produced by Australian (a) hardwood and (b) softwood mills



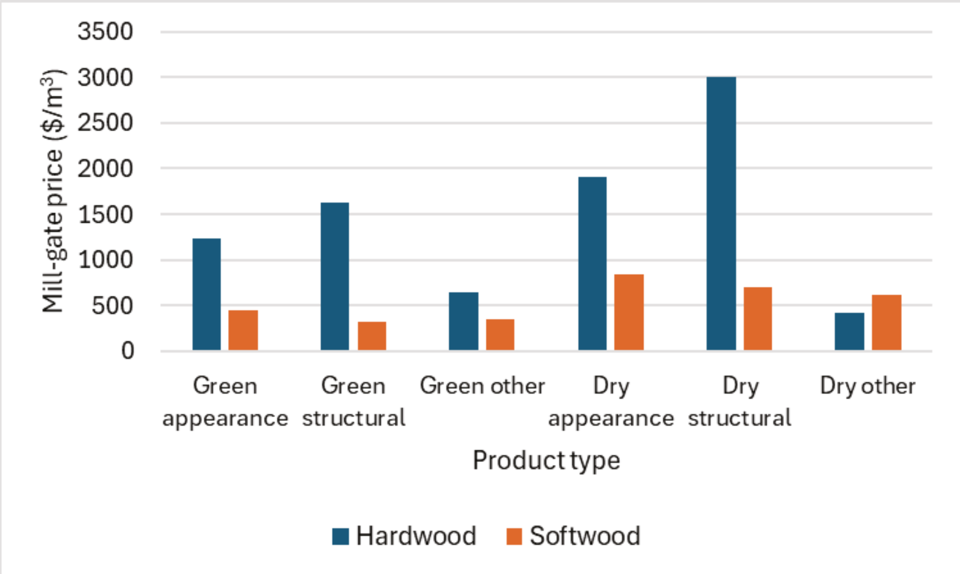
Note: Native forest hardwood rounds do service agricultural and landscaping markets, but available statistics were insufficiently detailed to permit an agricultural, landscaping and fencing rounds category for hardwood production. Furthermore, the reported volume of native forest hardwood agricultural, landscaping and fencing rounds used in Australia is likely to be substantially under-estimated by published statistics because harvest volumes of these log types on private land may not be recorded, as they bypass sawmills and post and pole mills, and go direct to on-farm-use or to wholesalers and retailers. This is less likely to occur with softwood plantation rounds, where harvest volumes are recorded by government agencies and plantation management corporations.

Sources: Dunn (2011), Wong et al. (2024), ABARES (2025c) and FWPA (2026, https://fwpa.com.au/industry-info/fwpa-public-information/).

Available native forest hardwood rounds statistics are likely under-estimating true production and consumption of landscaping and fencing rounds, as production from private land may not be recorded if it bypasses sawmills and post and pole mills, and goes direct to on-farm-use or to wholesalers and retailers. Plantation softwood rounds are used in agricultural and landscape rounds markets, such as vineyard poles and playground equipment. A higher proportion of sawn softwood output is lower-value sawn fencing and pallet timber (39%) than for sawn hardwood (28%).

Further evidence of market differentiation between hardwoods and softwoods is provided by Figure 2.5, which highlights that native forest hardwoods command much higher prices in the same broad product categories than plantation softwoods. In 2021-22, the weighted (by product volume) mill-gate price of sawn hardwoods was \$1259/m^3, while the weighted mill-gate price of sawn softwoods was \$604/m^3. This suggests the specific markets served by Australia's native forest hardwoods are not supplied by Australia's existing plantation estate.

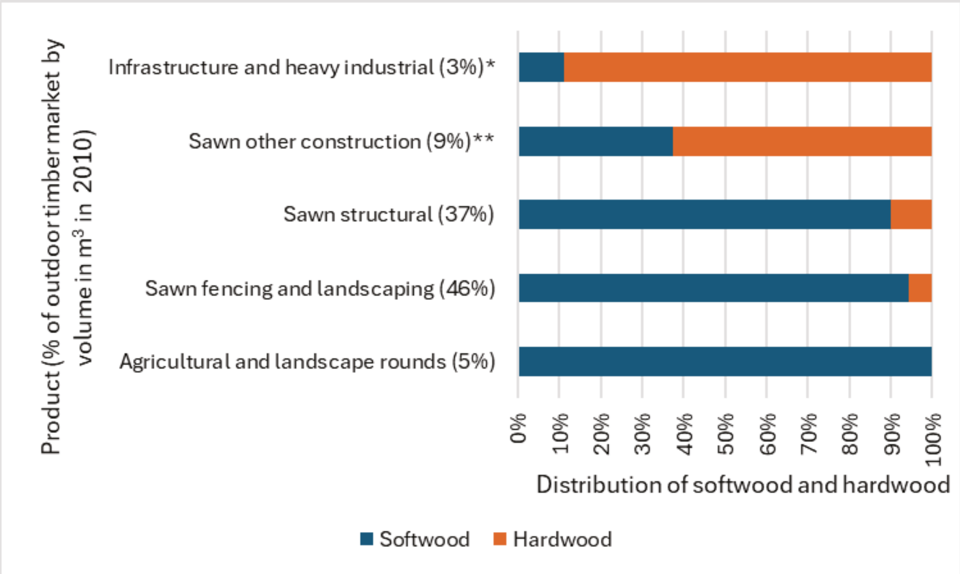
Figure 2.5. Australian mill-gate prices for native forest sawn hardwood and plantation softwood products in 2021-22 (AU$).



Source: Wong et al. (2024).

In 2010, the outdoor timber and infrastructure markets in Australia represented approximately 37 to 52 per cent of the apparent consumption of sawn and roundwood (Dunn, 2011). This broad category includes agricultural rounds, outdoor structural (e.g. deck framing), sawn residential decking and cladding, rounds and sawn fencing and landscaping timbers, piles and poles (e.g. for electricity distribution), and bridge and wharf timbers. The total size of this market in 2010 was about 5.89 M m^3 RWE (adjusting the estimates from Dunn (2011) to account for 35% sawn timber recovery and 80% roundwood recovery from log volume). This consisted of 0.85 M m^3 RWE of Australian native forest and imported hardwood, particularly merbau, and about 5.04 M m^3 RWE of softwood – mostly domestic, but also including pine imports from New Zealand and Chile, and western red cedar imports from Canada. Figure 2.6 reports the outdoor timber and infrastructure market categories, their proportionate contribution to total outdoor timber and infrastructure volume in 2010, and their breakdown by hardwood and softwood. Hardwoods dominated sawn other construction (e.g. decking, external joinery and cladding), as well as infrastructure and heavy industrial uses (e.g. electricity distribution poles, bridge and wharf timbers). The sawn structural category includes applications such as pergolas, balustrades, handrails, picket fencing and outdoor rooms, which were dominated by softwoods.

Figure 2.6. Contribution of softwood and hardwood to Australian outdoor timber and infrastructure markets



Note: The percentages in parentheses represent the proportion of the aggregate hardwood and softwood outdoor timber market

* Includes railway sleepers, mining timbers, boardwalk, bridge and wharf timbers, and poles and piles.

** Includes residential uses such as flooring, decking, cladding, mouldings, furniture and internal and external joinery.

Source: Adapted from Dunn (2011). RWE volume estimated by assuming 35% sawn timber recovery and 80% roundwood recovery from log volume.

3. Australian Domestic Timber Supply

This chapter quantifies Australia's forest resource estate and the volume of domestic solid wood production from the mid-1990s to the early 2020s.

3.1 National Forest Resource

Australia's total native forest and plantation estate area is reported by state and territory in Table 3.1. Land tenure breakdowns are provided for native forest. The softwood plantation estate is almost entirely on public land, while the hardwood plantation estate is mostly on private land.

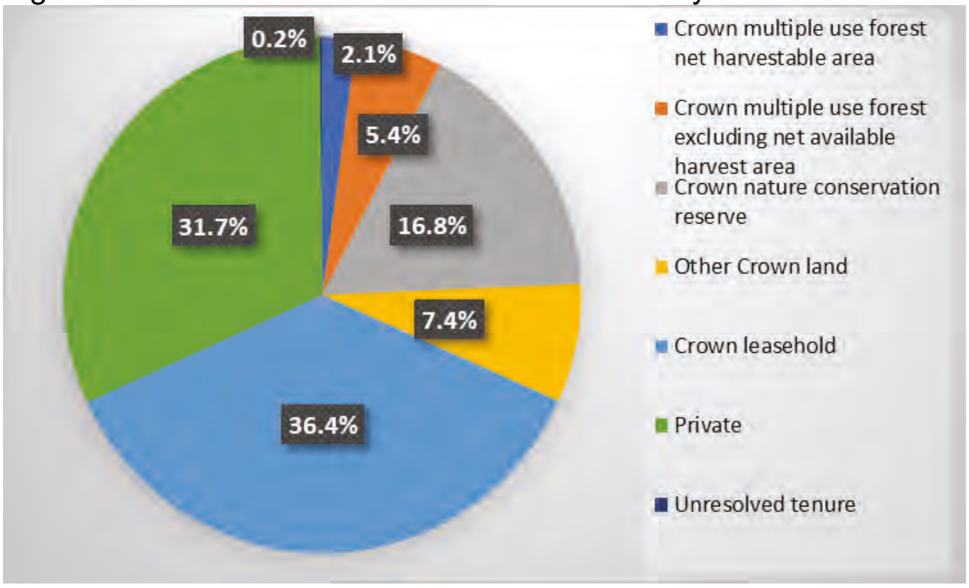
Table 3.1. Australia's native forest (2021) and timber plantation area (2023-24) by state or territory

Forest type and Tenure	Forest area by state, territory and nationally (1000s ha)								
	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
Native forest									
Crown multiple use [a]	1,857	3,162	2,948	16	1,294	645	0	5	9,927
Crown nature conservation	5,637	3,456	4,236	1,756	5,292	1,532	11	117	22,037
Crown other	829	127	932	72	6,938	377	486	1	9,762
Crown leasehold	3,913	0	27,428	1,406	5,414	8	9,749	8	47,926
Total Crown	12,236	6,745	35,544	3,250	18,938	2,562	10,246	131	89,652
Private	7,580	1,044	16,081	1,613	1,471	831	13,011	0	41,631
Unresolved tenure	66	0	126	3	0	0	23	0	218
Total native forest	19,882	7,789	51,751	4,866	20,409	3,393	23,280	131	131,501
Plantation forest									
Hardwood	55.0	159.5	18.0	40.5	174.9	189.4	36.3	0.2	673.8
Softwood	296.2	223.1	186.4	124.8	100.2	79.4	2.7	10.3	1,009.8
Total plantation	351.6	380.7	205.0	163.5	289.3	271.2	37.1	8.6	1,706.9

Note: a. These estimates do not account for changes in tenure since 2021, such as the closure of State Forests to timber harvesting in WA and Vic. The net area of Crown multiple use native forest that is actually available for harvesting was not available by state. The net area of Crown multiple use native forests available nationwide for harvesting in 2024 (after accounting for closure of WA and Vic) was 2.8 million hectares (ABARES, 2025b).
Source: ABARES (2025c).

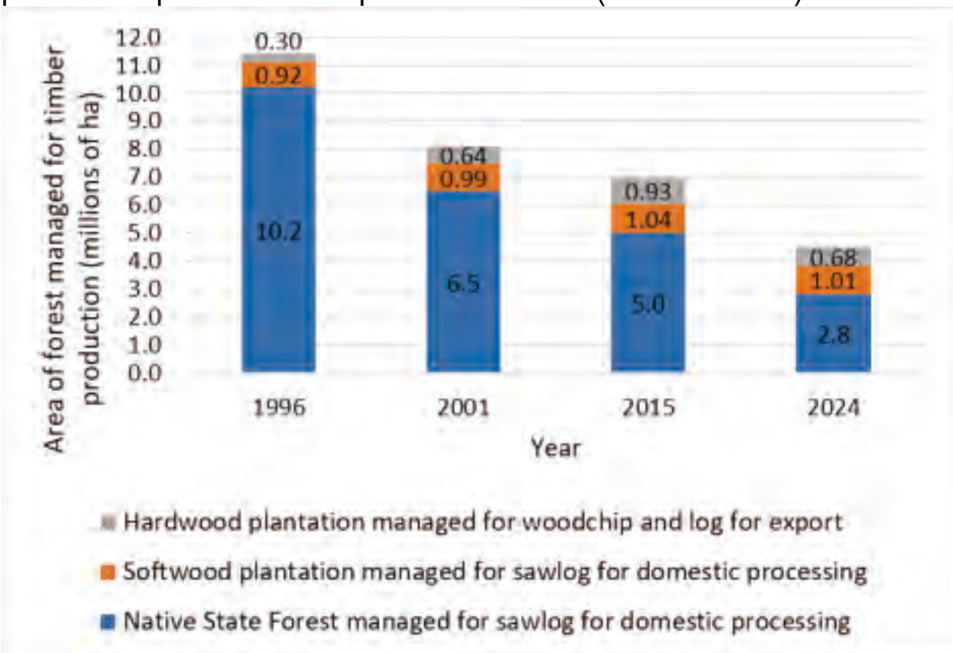
The national distribution of the 131.5 M ha of native forest by land tenure is indicated in Figure 3.1, with public native forests accounting for 32%. A relatively consistent national forest policy regime commenced in the 1990s with Australia's first National Forest Policy Statement (Commonwealth of Australia, 1992), which was implemented through ratification of Regional Forest Agreements (RFAs) from 1997. As indicated in Figure 3.2, the net harvestable area within Australia's State Forests in 1996 was 10.2 M ha (National Forest Inventory, 1998; ABARES, 2025b). The RFAs and ad-hoc government decisions progressively pursued domestic land sparing forest policies that transferred large proportions of State Forest to the strict conservation estate before additional substitute domestic timber resources were available (McAlpine et al., 2005; Venn, 2023; Timber Queensland, 2024). Consequently, by 2024, the net area of public multiple use forest available for timber harvesting had fallen to 2.8 M ha (National Forest Inventory, 1998; ABARES, 2025b).

Figure 3.1. National distribution of native forest by land tenure in 2024.



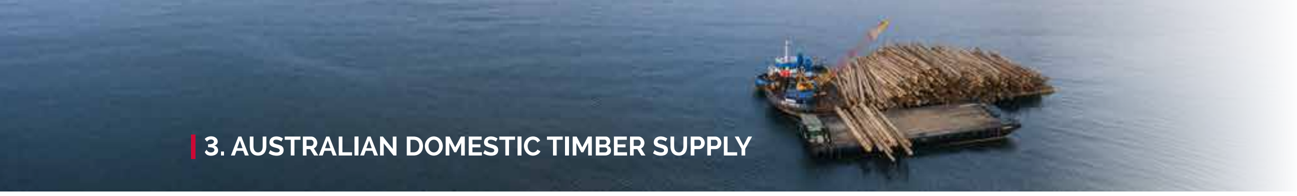
Source: ABARES (2025c)

Figure 3.2. Net harvestable area of multiple use public native forest, and area of public and private timber plantation forest (1996 to 2024)



Sources: National Forest Inventory (1998), ABARES (2024c) and Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee (2024).

Private native forest (PNF) on freehold and leasehold land accounts for 89.6 M ha (68%) of Australia's native forest cover, of which 21.4 M ha is potentially available and suitable for timber production (Davey and Dunn, 2014; Montreal Process Implementation Group for Australia and National Forest Inventory Steering



Committee, 2024). However, there are no records about how much of this area is managed by landholders for timber production, and about 85% of the potentially available and suitable area has very low productivity in its current condition, at less than 0.3 m^3/ha/y of merchantable wood (Davey and Dunn, 2014). Nevertheless, productivity of the PNF estate could be greatly improved. For example, Francis et al. (2024) found that 1.2 M ha of PNF in southern Queensland alone could achieve growth rates of at least 1.0 m^3/ha/y with improved management.

A goal of the National Forest Policy Statement was to incentivise active management of commercially important PNF to complement the commercial wood production and nature conservation values of public native forests (Commonwealth of Australia, 1992). However, in practice, government incentives focussed on plantation establishment, which excluded commercially important PNF. This was unfortunate, since PNF regrowth that is periodically re-cleared to increase pasture production could alternatively have been managed as silvopastoral systems at much lower opportunity and establishment costs than conversion of cleared agricultural land to timber plantations. Sovereign risk has been a serious impediment to investment in sustainable PNF management for decades (Venn, 2023). Indeed, the latest round of PNF policy discussions in Queensland was publicly announced in 2019, with no decisions made by the time of writing in mid-2026 (Bowden, 2023; Wood Central, 2023; Queensland Government, 2024). Landholders continue to make economically rational decisions to de-risk their businesses by clearing commercially important PNF to maximise livestock income where they have the right to do so (Venn, 2023; Venn et al., 2024).

Strong intent to reduce Australia's reliance on native forest harvesting was signalled by the 1997 release of Vision 2020 (Plantation 2020 Vision Implementation Committee, 1997), a joint initiative of the federal and state governments, and the timber industry, that aimed to treble Australia's timber plantation estate to 3 M ha by 2020 (35% achieved by 2024). The federal government renewed its commitment to plantation forestry in 2018 with its Growing a Better Australia plan (Department of Agriculture and Water Resources, 2018) to increase the plantation estate by 400,000 ha within a decade. Australia's plantation area decreased by 226,000 ha (93% hardwood) between 2018-19 and 2023-24 (ABARES, 2025d). In 2023-24, Australia's total timber plantation area was about 1.7 M ha, down from 2.0 M ha a decade earlier, as illustrated in Figure 3.2.

About 90% of the nation's 1.0 M ha of long rotation (~30 year) sawlog producing softwood plantations were established prior to the 1990s. This was largely achieved on public land through Softwood Forestry Agreements between the federal and state governments from the 1960s to address the national shortage of softwoods and to complement Australia's natural abundance of high-quality hardwoods (Carron, 1985). The area of softwood plantations has been static since 2000-01, indicating there is limited capacity to expand fibre production from Australia's softwood plantation estate for the foreseeable future.

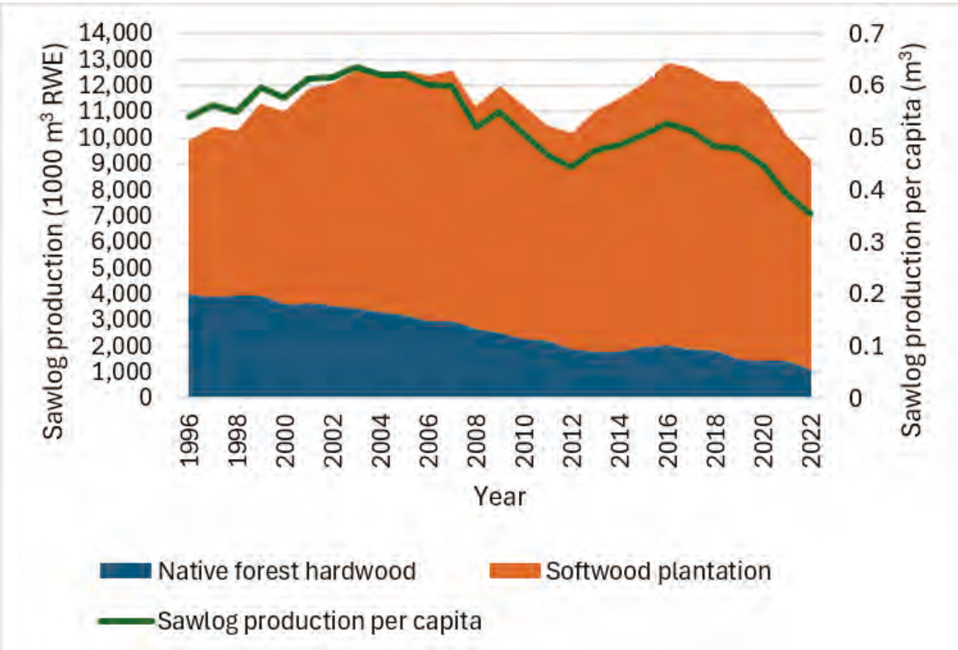
Almost all the plantation area expansion in Australia since the mid-1990s was in short rotation (~12 to 14 year) hardwoods established on private land with species suitable for pulp and paper production (not sawn wood products). This expansion was supported by considerable indirect federal government investment (de Fegely et al., 2011; Burns et al., 2015; Downham and Gavran, 2020). With 95% of annual production exported as logs and woodchip and most of the remainder going to domestic paper manufacture, the hardwood plantation estate has made minimal contribution to the domestic solid wood market (Whittle, 2019; Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2024; ABARES, 2025b). Furthermore, the area of hardwood plantations in Australia has been steadily decreasing due to poor financial performance, with the estate decreasing by 32% (317,000 ha) from its peak in 2008-09 to 2023-24 (Downham and Gavran, 2020; Legg et al., 2021; ABARES, 2024c, 2025d).

Whittle et al. (2019) estimated that under existing policy settings around 4770 ha of new short rotation hardwood plantations and 24,010 ha of new long-rotation softwood plantations could become economically competitive with existing agricultural land use throughout Australia by 2050.

3.2 Domestic Log Harvest and Solid Wood Product Manufacture

Figure 3.3 illustrates sawlog production in Australia from 1996-97 to 2022-23. Aggregate (state and private) native forest sawlog harvest volume was 4.0 M m^3 in 1996-97, with public forest closures reducing annual production to 1.1 M m^3 in 2022-23. By the early 2020s, aggregate softwood and native forest sawlog volume was less than aggregate production in the mid-1990s. With population growth of 42% over the period, per capita sawlog production of 0.54 m^3/person/y in 1996-97 had declined by 35% to be only 0.35 m^3/person/y in 2022-23.

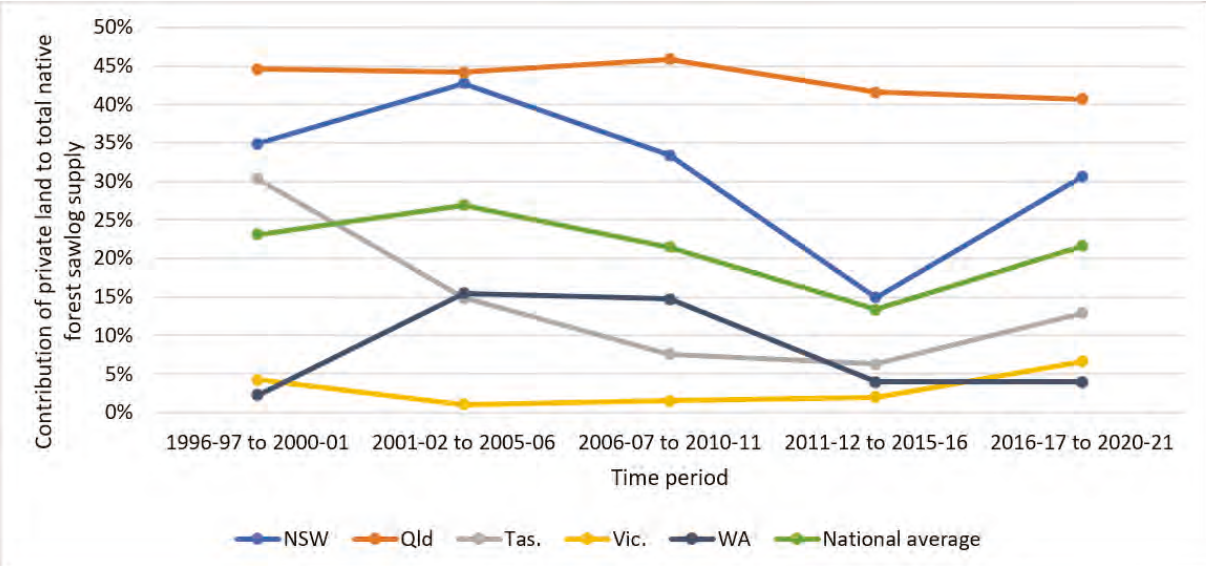
Figure 3.3. Aggregate sawlog production and sawlog production per capita, 1996-97 to 2022-23



Note: See Appendix A.1.3 for methods for estimation of roundwood equivalent (RWE) volumes.
Source: ABARES (2024b).

Estimating the proportion of native forest log supply from private versus public land is challenging, often relying on sawmill surveys. Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee (2024) published average annual aggregate (public and private) and average annual private native forest sawlog harvest volumes for the period 1996-97 to 2020-21, from which the percentage contribution from private land has been reported in Figure 3.4. The national average contribution of private native forest to native forest sawlog volumes has fluctuated, but proportions were similar at the beginning and end of the period – 23% and 21%, respectively. There has been a substantial decline in the contribution of Tasmanian private native forests since 1996-97. The contribution of Victorian and Western Australian private native forests was low throughout relative to Queensland and New South Wales. With the shutdown of harvesting on public land in Victoria and Western Australia in 2024, private native forests are likely to provide much higher proportionate contributions post-2024. Land clearing for mining in the public jarrah forests of Western Australia will continue to supply some native forest timbers from public land in that state.

Figure 3.4. Contribution of private land to total native forest sawlog supply, 1996-97 to 2020-21



Note: As described in the text, the average contribution of private native forests in Queensland may be 55% over this period.

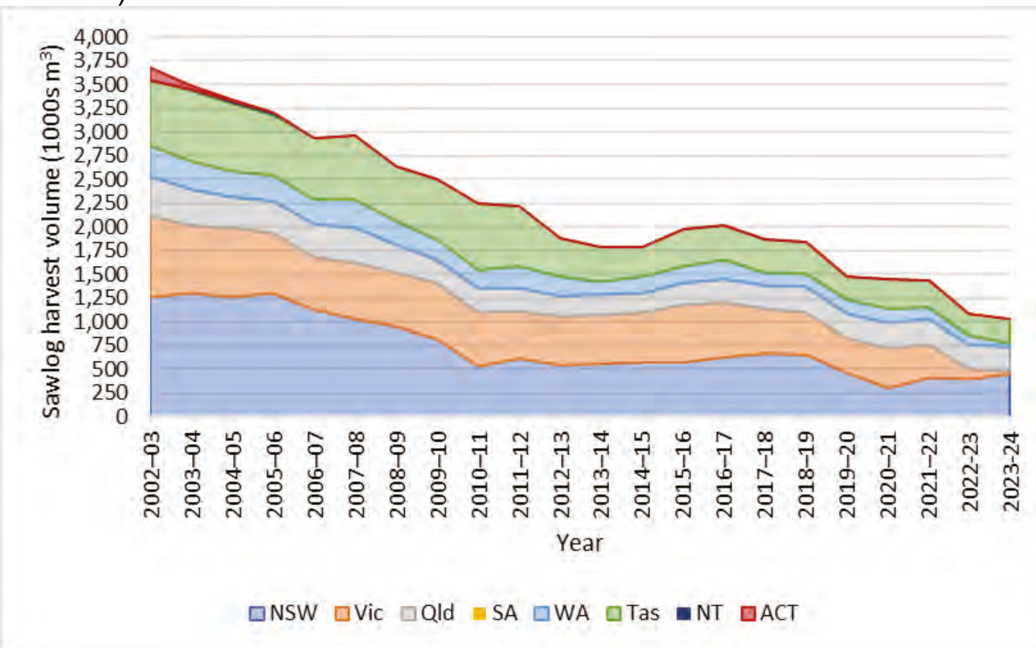
Source: Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee (2024).

The contribution of private native forest to Queensland's log volume in Figure 3.4 is low relative to other published estimates for the state that cover the same and earlier time periods (Carron, 1985; DPI Forestry, 1998; Bureau of Rural Sciences, 2004; State of Queensland, 2016). For example, using Queensland Government and ABARES data, Francis et al. (2020) found the annual private contribution to Queensland's native forest hardwood supply varied between 40% and 70% over the period 2004-05 to 2016-17, with a mean of 55%. The discrepancy between other published estimates and the estimate in Figure 3.4 may be the result of a native forest harvest volume reporting error – the average annual aggregate (public and private) native forest sawlog harvest volume published for Queensland in Montreal

Process Implementation Group for Australia and National Forest Inventory Steering Committee (2024) is substantially higher than in ABARES (2025c). This may have had the effect of reducing the percentage contributed by private land. The other state volumes are consistent between the two datasets.

Figure 3.5 illustrates native forest sawlog harvest volumes by state and territory from 2002-03 to 2023-24, with the State Forest shutdowns in Victoria and Western Australia in 2024 evident. All of this volume is processed domestically. Figure 3.6 reports softwood plantation sawlog production by state and territory. Since 2021-22, aggregate softwood plantation sawlog production has been below the harvest volume in 2002-03.

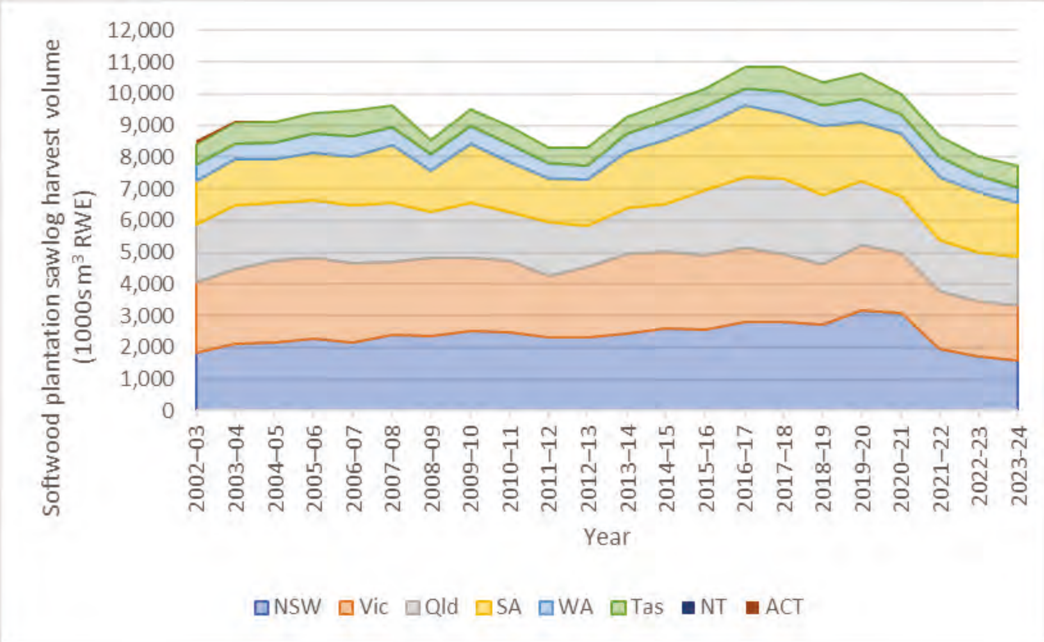
Figure 3.5. Native forest sawlog harvest volume by state or territory (2002-03 to 2023-24)



Source: ABARES (2025c)

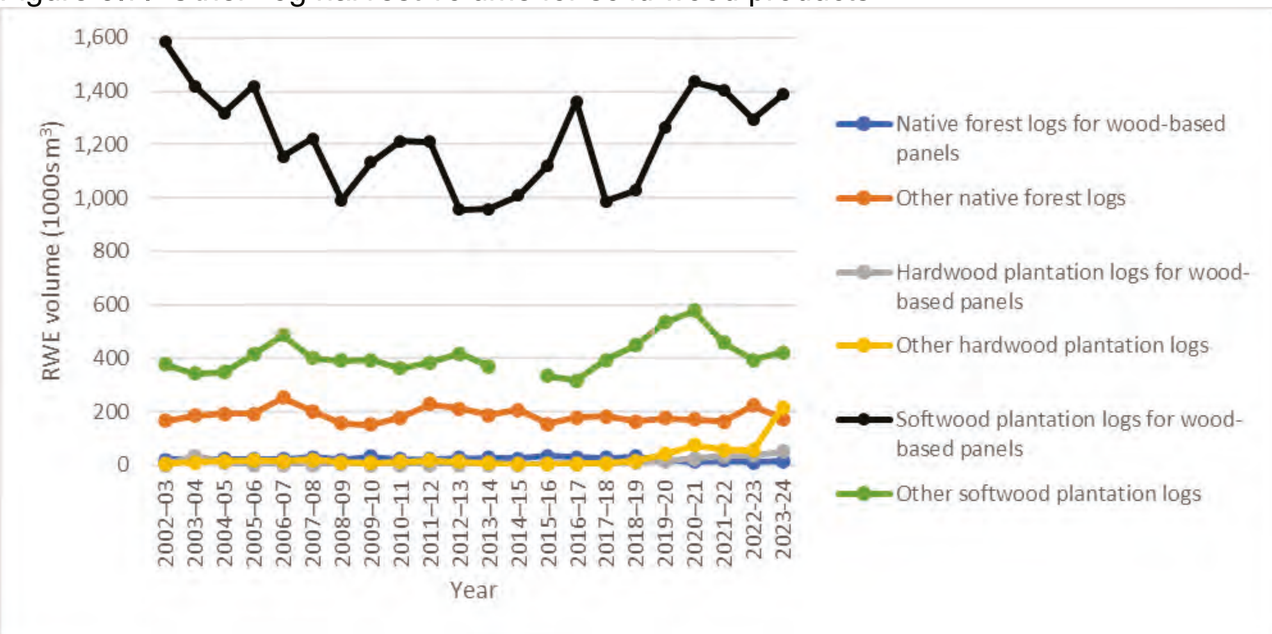
The national harvest trend in ‘other’ solid wood product log types is illustrated in Figure 3.7. These logs include softwood plantation agricultural and landscaping rounds, native forest electricity poles and girders, and pulplogs for wood-based panel manufacture (engineered wood products; EWPs). With the exception of ‘other hardwood plantation logs’ (which were mostly exported), these log types were utilised domestically.

Figure 3.6. Softwood plantation sawlog harvest volume by state or territory (2002-03 to 2023-24)



Source: ABARES (2025c)

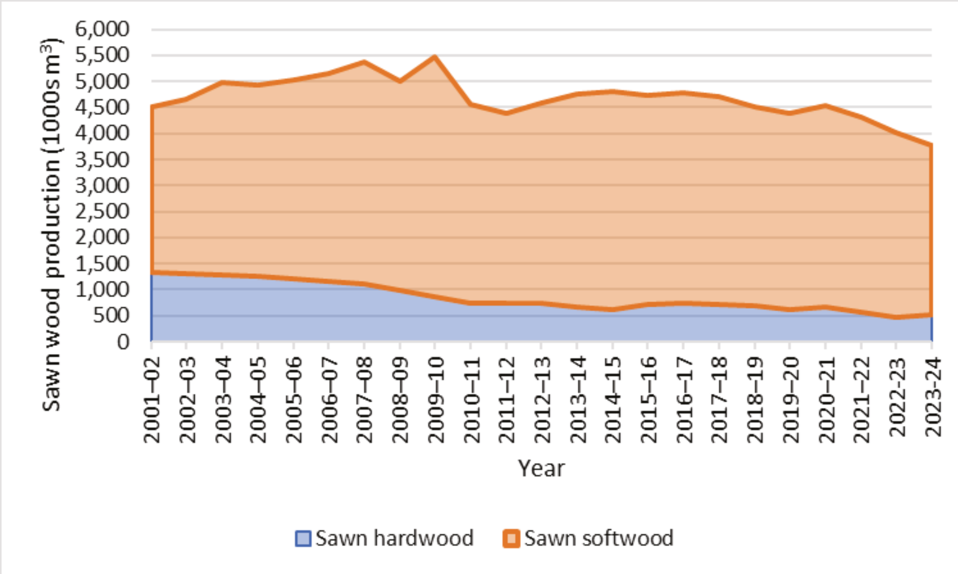
Figure 3.7. 'Other' log harvest volume for solid wood products



Note: Other native forest logs include electricity distribution poles, piles, bridge girders and fencing. Softwood plantation other logs include landscaping and agricultural rounds and fencing.
Source: ABARES (2025c)

The time series of domestic sawn wood production from native forest hardwood and plantation softwood sawlogs is illustrated in Figure 3.8. Both Australia's sawn softwood production and aggregate sawn hardwood and sawn softwood production peaked in 2009-10. Average aggregate sawn wood production declined 13% between the periods 2001-02 to 2005-06 and 2019-20 to 2023-24.

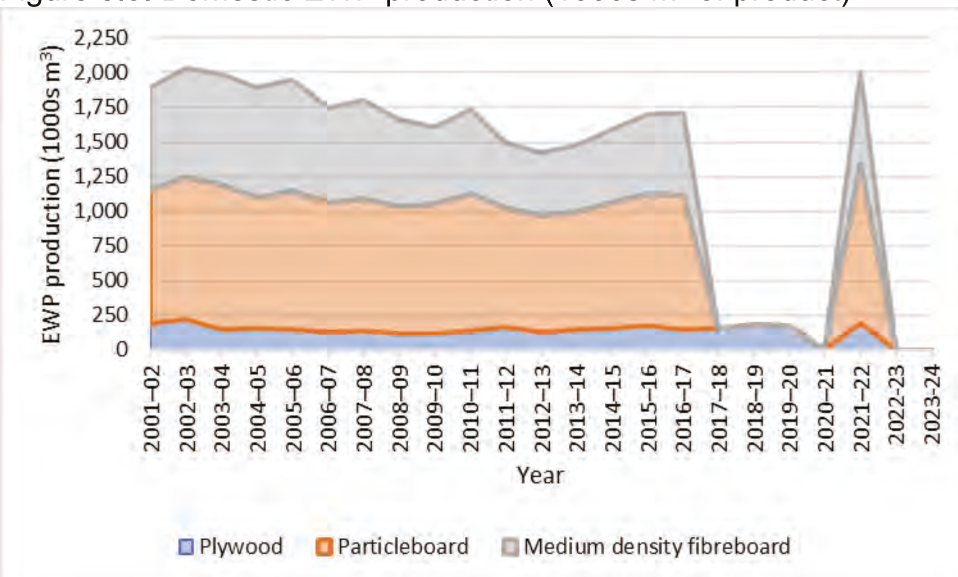
Figure 3.8. Domestic sawn native forest hardwood and sawn plantation softwood production (1000s m^3 of product)



Source: ABARES (2025c).

EWPs, principally particle board (PB), medium density fibre board (MDF) and plywood, are important components of Australia's solid wood production. The time series of domestic EWP manufacture 2001-02 to 2023-24 is illustrated in Figure 3.9, indicating a decline between 2001 and 2013, but a return to equal the level of production in 2002-03 by 2021-22. ABARES no longer regularly reports data for EWP production due to mill confidentiality.

Figure 3.9. Domestic EWP production (1000s m^3 of product)



Note: Due to business confidentiality, Australian particle board and medium density fibreboard production has not been reported since 2016-17, and plywood production has not been reported since 2019-20. However, all three were reported in 2021-22.
Source: ABARES (2025c).

Plywood production in Australia generally uses sawlog, and MDF and PB use sawmill residues in addition to pulp logs for wood-based panels. Australian EWP manufacturers primarily (>95%) use softwood fibre, and although there are no official residue feedstock statistics, softwood sawmill residues are known to be a major input for PB and MDF, which together account for 90% of the nation's EWP production (Lock and Whittle, 2018; Whittle, 2019; ABARES, 2025c). Over the period 2001 to 2022, EWP manufacturers used between 0.96 M m^3/y and 1.58 M m^3/y softwood plantation pulp logs (with no temporal trend; Figure 3.7) and small volumes of native forest and hardwood plantation pulp logs, which slowly increased over time to 64,000 m^3/y in 2022-23 (ABARES, 2025c). Despite softwood and hardwood plantation feedstock growing substantially since 1996, EWP manufacture did not expand. Domestic EWP manufacture has not made a net positive contribution to offset reduced sawlog supply from native forests since 2001-02.

3.3 Summary and Implications of Domestic Solid Wood Production, 2019-20 to 2023-24

Table 3.2 summarises mean annual domestic log harvest for solid wood products and the volume of solid wood products manufactured for the period 2019-20 to 2023-24. Justification for excluding hardwood plantations from this assessment is provided in Section 3.4. Average aggregate log harvest volume for solid wood product manufacture was about 12.3 M m^3/y. About 89% of intermediate and finished product volume was produced from softwood plantations, with the remainder from native forests.

Table 3.2. Summary of mean annual domestic solid wood production 2019-20 to 2023-24

Log or product type	Mean annual volume (1000s m^3/y)		
	Native forest hardwood	Plantation softwood	Total
Log types in RWE or log volume			
Sawlog [a]	1295	9013	10,308
Wood-based panel log	15	1356	1371
'Other' log [b]	182	477	659
Total log volume	1492	10,846	12,338
Intermediate and finished product volume			
Sawn wood	575	3624	4199
EWPs [c]		2004	2004
'Other' product [d]	146	382	527
Total product volume	721	6010	6730

Notes: a. Includes logs used for the manufacture of plywood and hardwood logs include logs from which railway sleepers are cut.
b. 'Other' native forest logs include electricity distribution poles, piles, bridge girders and fencing. Softwood plantation 'other' logs include landscaping and agricultural rounds and fencing.
c. Australia's hardwood versus softwood EWP production is not available, however, softwood plantations accounted for 92% of wood-based panel log volume over the period 2001-02 to 2023-24. Softwood sawmill residues are also important in Australian EWP manufacture. The only year in this period for which EWP volume was available was 2021-22.
d. The intermediate or finished volume of 'other' product has been estimated as 80% of log volume, which assumes that most of this volume (described as poles, piles, bridge girders and fencing) is for roundwood products, not sawn timber.

Source: ABARES (2025c).

Aggregate log harvest volume for the manufacture of solid wood products in the early 2020s is less than in the early 2000s and similar to levels in the mid-1990s 1990s (ABARES, 2024b). This is a concern for sovereign timber capacity given Australia's population grew 42% between the mid-1990s and 2022-23 (https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/sep-2025). There has been a dramatic change in product mix since the mid-1990s, with native forest supplying about 40% of solid wood products at that time (ABARES, 2024b). Given the market differentiation between native forest hardwoods and plantation softwoods, this may be driving demand for imports; a question that is addressed in Chapter 6.

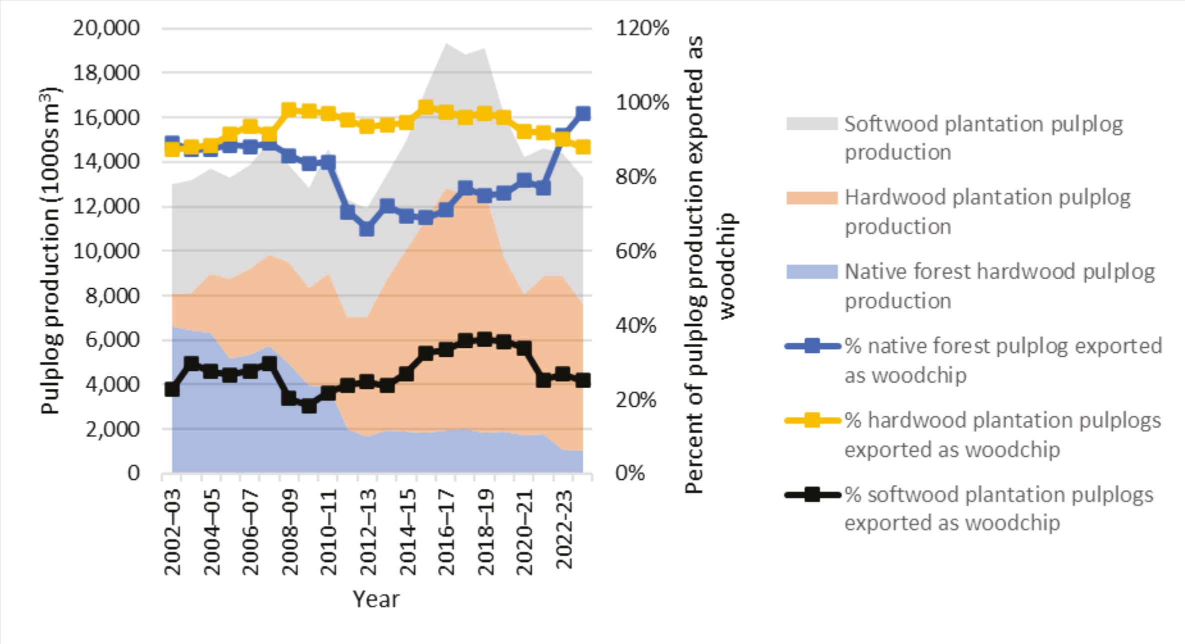
Domestic harvest of logs for solid wood product manufacture in the 2020s is considerably below the domestic demand of 18 to 20 M m^3 RWE/y, summarised in Figure 2.2. With the softwood plantation area static since 2001, there is limited capacity to expand sawlog production from the existing plantation estate (ABARES, 2024b, 2025d). The status of the hardwood plantation estate is described in Section 3.4. Industry has raised concerns that achievement of national house construction targets will require increased reliance on imported wood (FWPA, 2025).

3.4 Justification for Excluding Pulp logs in General and Australia's Hardwood Plantation Estate from Analysis of Australian Solid Wood Supply

Domestic native forest, softwood and hardwood plantation pulp log volumes directed to domestic EWP manufacture have been captured as feedstock for solid wood products in this report. However, remaining domestic pulp log volume and imported pulp logs, pulp and paper products have been excluded from this report to maintain focus on the solid wood market. Markets for paper products are structurally distinct from markets for solid wood. The pulp log exclusion resulted in the effective exclusion of Australia's hardwood plantation estate from analysis, which is justified below.

Over the period 2002-03 to 2022-23, 92.3% of all pulp logs grown in Australia were converted to woodchip and pulp for export or for domestic manufacture of paper (ABARES, 2025c). Figure 3.10 illustrates pulp log harvest volume and the proportion exported as woodchip by forest resource type. Growth in pulp log harvest volume was largely due to maturing short rotation hardwood plantations and this was almost entirely exported rather than entering Australian solid wood supply chains (e.g. via EWPs).

Figure 3.10. Domestic pulp log production and proportion exported as woodchip, 2002-3 to 2023-24



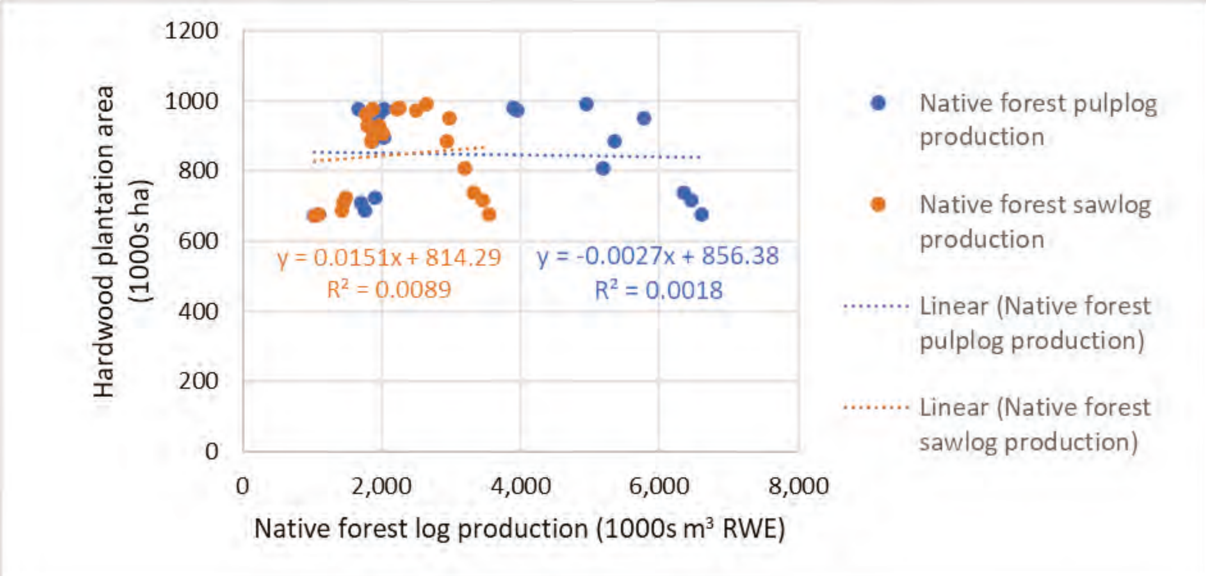
Source: ABARES (2025c).

The contribution of pulp logs over the study period to Australian solid wood production (through EWP manufacture) was small, averaging 7.7% of pulp log harvest volume (and equivalent to 10.1% of sawlog harvest volume). In addition, the volume of pulp log allocated to EWP manufacture decreased during the study period while native forest sawlog production decreased and solid wood imports increased (ABARES, 2025c). Figure 3.11 illustrates the structural decoupling between the native forest sector, and the hardwood plantation estate – there is no relationship between native forest pulp log or sawlog production, and hardwood plantation area; R^2 < 0.2% and R^2 < 0.9%, respectively. Therefore, the expansion of the hardwood plantation estate has not constituted a market response to reduced native forest timber supply. Pulp log production did not expand to substitute for native forest sawlog production or to offset solid wood imports.

Development of processing technologies may facilitate increased utilisation of Australia's hardwood plantations for domestic solid wood production in the future, including in EWPs (Gutierrez et al., 2023; Millaniyage et al., 2024). However, as indicated by Figure 3.12, generous federal government tax concessions (de Fegely et al., 2011; Burns et al., 2015; Downham and Gavran, 2020) largely incentivised expansion of hardwood plantations that have produced woodchip and logs for export (Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2024), rather than solid wood products for domestic consumption.

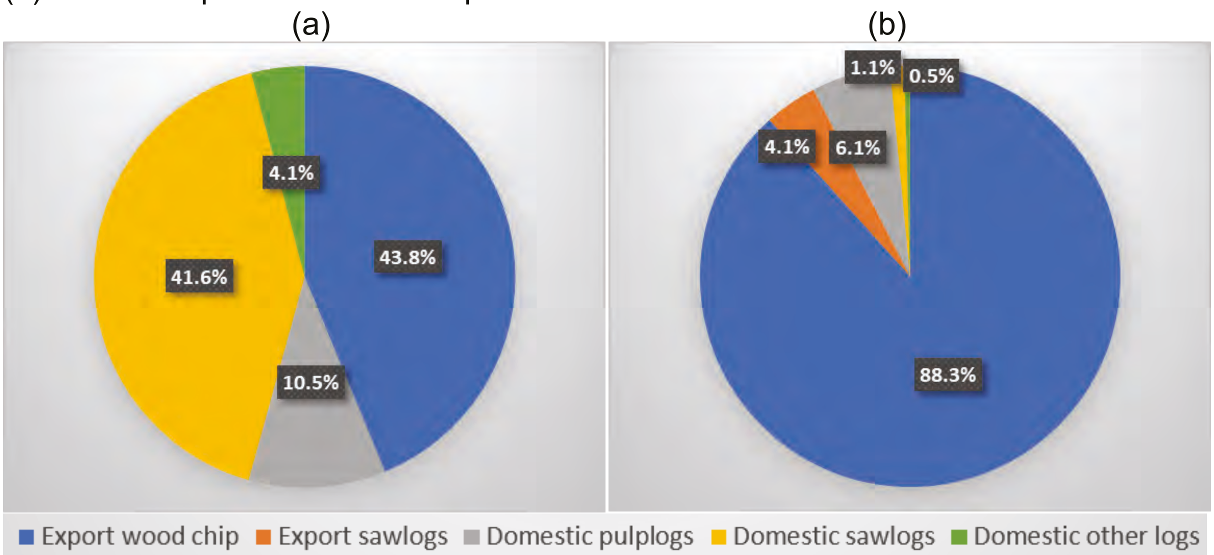
In contrast, Australia's native forests have been managed for sawlogs and other solid wood products (e.g. poles for electricity distribution), with pulp logs produced as a joint product (e.g. from suppressed trees and low-quality logs within a sawlog tree). Sawlogs and other native forest logs processed domestically represented 46% of native forest harvest volume, but only 1.6% of hardwood plantation harvest volume (Figure 3.12). Sawlog production from hardwood plantations for domestic processing is likely to increase in the future, such that it will not be appropriate to exclude hardwood plantations in future analyses.

Figure 3.11. The absence of a relationship between Australian native forest sawlog or pulp log production and hardwood plantation area (2002-03 to 2023-24)



Source: ABARES (2025c).

Figure 3.12. Composition of hardwood log harvest volume from (a) native forest and (b) hardwood plantations for the period 2002-03 to 2023-24

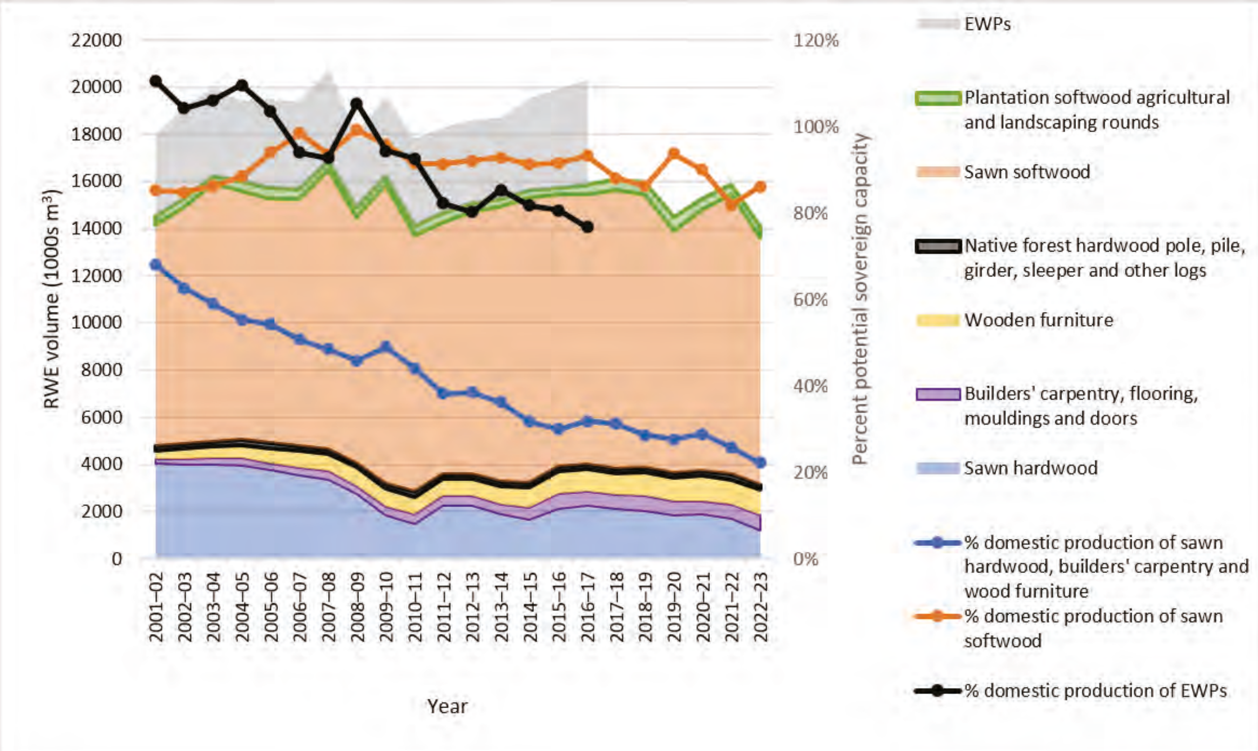


Source: ABARES (2025c).

4 Australia's Potential Sovereign Capacity in Solid Wood Products

Figure 4.1 reports Australia's apparent consumption of solid wood products (area plot) from Chapter 2, and potential sovereign capacity in percent (the line plots), which is domestic production from Chapter 3, divided by apparent consumption. This percentage does not reflect the actual proportion of domestic production consumed in Australia, because some Australian production is exported (see Chapter 5). The percentage provides a measure of the potential for domestic production to service domestic demand.

Figure 4.1. Australia's apparent consumption of solid wood products (area chart), and percent potential sovereign capacity (line plots), 2001-02 to 2022-23



Note: See Appendix A.1.3 for methods for estimation of roundwood equivalent (RWE) volumes.
Sources: ABS (2024a) and ABARES (2024b, 2025c).

Potential sovereign capacity in sawn softwood has remained relatively steady since 2001-02 at between 85% and 95%. Woods and Houghton (2022) estimated the average import share of the Australian sawn softwood market was 19.7% over the period 2004-05 to 2020-21. With the softwood plantation estate not expanding since 2001 and thus having limited capacity to expand production within the next three decades, the authors projected a domestic supply gap of 40.5% of the market before 2050. They estimated bridging this sawn softwood supply gap requires expansion of the softwood plantation estate by 468,000 ha.

Australia was a net exporter of EWPs (by volume) in the early 2000s (potential sovereign capacity >100%). However, by 2016-17 (most recent available data), Australia was a substantial net importer, with potential sovereign capacity at about 77%. With Australia's imports of EWPs rapidly rising (see Chapter 5), potential sovereign capacity in EWPs is likely to be less than 77% in 2022-23.

Australia's potential sovereign capacity in sawn hardwoods, builders' carpentry and wood furniture dramatically contracted from 68% in 2000-01 to 22% in 2022-23. This largely reflects the decline in native forest hardwood production in the absence of domestic hardwood plantations providing feedstock for solid wood product substitutes at scale.

5. Australia's Engagement in International Timber Trade

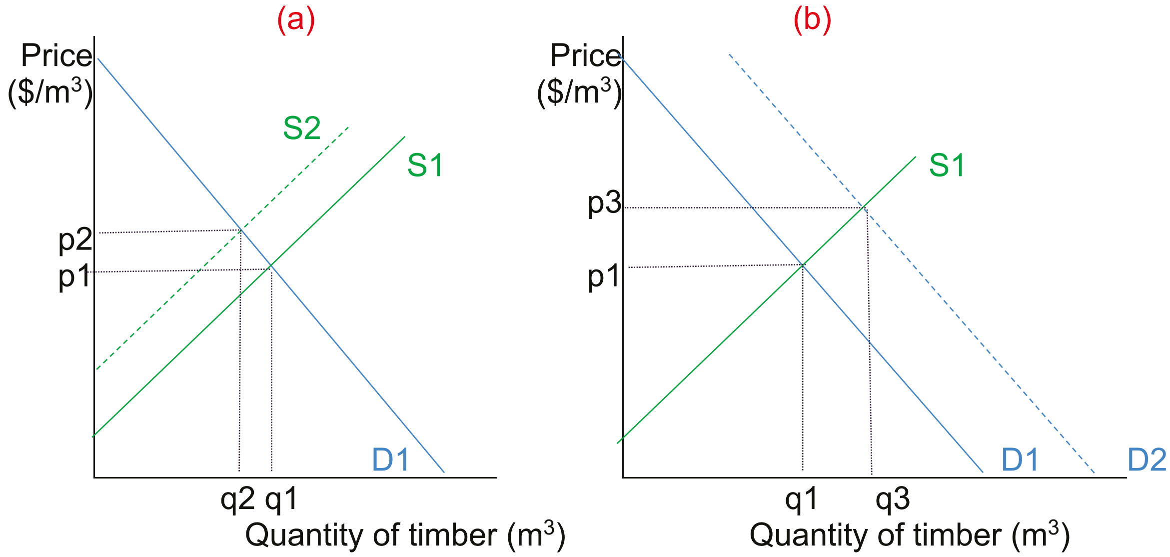
The purpose of this chapter is to quantify Australia's rapidly increasing reliance on imported solid wood since the mid-1990s. The chapter begins with simple international trade theory to provide an explanatory framework for why Australia's declining sovereign capacity in timber production, coupled with free trade with nations that have weak property rights, environmental and labour laws, is increasing Australia's reliance on imported timber. The volumes and countries of origin of Australia's imports are reported. The nation's solid wood product exports and the trade deficit in wood products have been summarised. Finally, comments are made about the domestic economy impacts of increasing reliance on imported timber.

5.1 Principles of Supply and Demand in the Context of Australia's Timber Market, and their Impact on Prices and Quantities

The theoretical framework provided by the economic laws of supply and demand in a market economy provides a clear representation of changes in Australia's sovereign capacity in wood products. This section commences with an illustration of the Australian timber market without trade (indicative of Australia before the 1990s with protective tariffs), followed by an illustration of the timber market with trade.

Figure 5.1 illustrates the market for timber in Australia assuming a free (unrestricted) domestic competitive market, but no international trade (i.e. autarky). The y-axis tracks the market price of timber and the x-axis the quantity of timber supplied and demanded. In both panels (a) and (b), the line labelled D1 is the 'demand curve' that tracks the willingness of Australian consumers in aggregate to pay for particular quantities of timber. At high prices, few people are willing to buy small quantities of timber, so the quantity of timber demanded will be low. Consumers might choose to purchase substitutes instead, such as steel, concrete, plastic, brick and carpet. As the price decreases, people are willing to purchase more timber.

Figure 5.1. Australia's timber market in autarky (no trade) illustrating a (a) contraction in supply and (b) expansion of demand



The line labelled S1 represents the domestic supply of timber or willingness of sellers to sell. S1 tracks the cost of timber production per unit of timber. Eventually the supply curve must rise, as illustrated, signalling that additional timber supply can only be brought into the market with rising prices. This occurs because, eventually, costs of production rise due to factors such as longer log haul distances, the need to use lower quality log types or species that result in lower sawn wood recovery from log volume, or the need to put on a late-night shift of workers to increase output. In panels (a) and (b), the market will initially be in equilibrium at the quantity where the willingness of sellers to sell (S1) equals the willingness of consumers to buy (D1). This is at an equilibrium price of p1 and quantity q1.

However, markets are frequently subjected to shocks that impact the market equilibrium. For example, timber harvest restrictions in native forests could reduce supply. This is illustrated in panel (a) by the left and upward shift of the supply curve to the dotted S2, which reflects the fact that there is less timber available in the market at each and every price. The operations of some timber producers will be less efficient due to the reduction in log availability – they may need to source logs from further away or use lower quality logs or reduce throughput at the mill and so have declining cash flow to cover fixed costs of production. This might cause some sawmills to shut down.

The market can no longer supply quantity q1 at price p1. Some consumer projects will be impacted by the timber shortage brought on by the timber harvest restrictions. Some consumers will be willing to pay a higher timber price to ensure they receive their timber requirements out of the smaller available timber supply. This is captured in panel (a) by Australian consumers 'moving up' along D1 (economising on wood consumption as prices rise) until a new timber market equilibrium is reached at the higher price p2 and lower quantity q2. Not all consumers will be willing and able to consume as much timber as they would have before the timber harvest restrictions. Some projects will be delayed, and some consumers will switch to non-timber substitutes. The overall effect is that a reduction in domestic timber supply will raise timber prices and reduce the quantity of timber produced and sold, likely affecting the number of construction projects that can be completed.

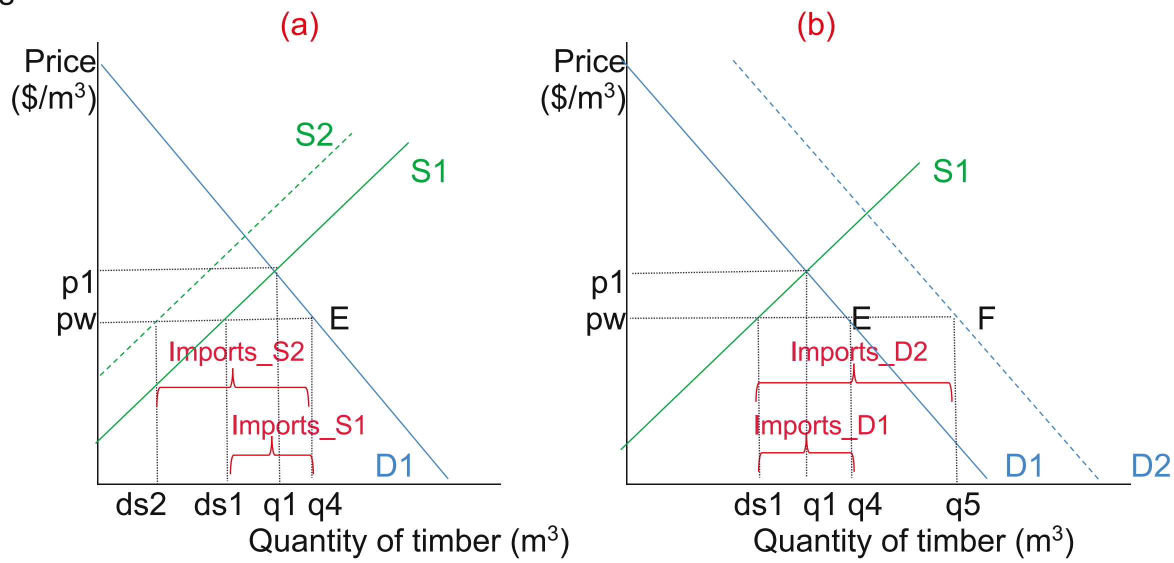
In Figure 5.1 panel (b), the timber market begins at the same initial market equilibrium p1, q1; however, this time there is a demand shock, such as government policy incentivising consumers to bring forward their house construction plans. This is illustrated by a shift to the right of the demand curve to D2 – consumers are willing to pay more for each and every unit of timber to take advantage of the government house building incentives. At a price p1, suppliers cannot supply all the timber now demanded by consumers. The costs of accessing a greater quantity of logs and increasing sawn timber output from mills to meet the demand will raise costs of production at the margin. Suppliers expand production along their supply curve until a new market equilibrium is reached at the higher price p3 and higher quantity demanded q3.

In the medium term, say 3 to 10 years, the higher domestic timber prices revealed by panels (a) and (b) may encourage adoption of processing technologies that increase solid wood product yield from log volume. Higher timber prices could also promote increased forest management for timber production, which could grow timber supply in the long-run – 15+ years – including via silvicultural treatment in native forests and expansion of timber plantations. These impacts are not illustrated in panels (a) or (b), but would have the effect of eventually shifting the supply curve down and to the right, increasing the quantity of timber that can be supplied to market at each and every price. However, in an economy like Australia's, which is open to international trade, the expansion in domestic supply may not occur without substantial policy shifts because of the ease with which Australia can import low-cost timber.

Figure 5.2 better represents the reality of the Australian timber market with international trade. The same supply and demand curves are illustrated in Figure 5.2 panels (a) and (b) as in Figure 5.1. However, Australia can now import timber at the world market price for timber, pw, which is below Australia's autarky equilibrium price p1. If this was not true, then Australia would have very little incentive to import timber. As described in Chapter 7, Australia's relatively high cost of timber production can be largely explained by the cost of regulatory compliance with property rights, environmental and labour laws compared to the elevated-risk nations that have supplied more than 80% of the growth in Australia's imports over the last 30 years, including China and Russia (see Section 5.2).

Domestic producers face international competition that effectively caps the domestic timber price to pw. From Australia's perspective, the world supply of timber is close to perfectly elastic (i.e. horizontal world supply curve at the price, pw). This is because annual growth in Australia's demand for imports (e.g. additional 100,000 m^3 RWE) is small relative to the volume of timber traded internationally (e.g. 231 M m^3 of exported product volume (not RWE) in 2024, including sawn wood and EWPs, but excluding unprocessed logs and further processed wood products such as builders' carpentry and wood furniture; https://www.fao.org/faostat/en/#data/FO, 15 June 2026). The market equilibrium will be at point E, where the world price intersects domestic demand – price pw and quantity q4. Overall timber consumption is higher than without trade (q4 vs q1) at a lower market price (pw vs p1); however, domestic producers are only able to competitively supply ds1, with contraction in the domestic timber industry relative to autarky of q1 – ds1. Imports satisfy q4 – ds1 of domestic demand.

Figure 5.2. Australia's timber market with international trade



In this market environment, if Australian policy reduced domestic timber supply from S1 to S2, as illustrated in Figure 5.2 panel (a), the market equilibrium will not shift from E. Instead, domestic supply contracts from ds1 to ds2 and imports expand from q4 – ds1 to q4 – ds2. With easy access to low-cost imports, there is limited incentive to undertake medium- or long-run investments to increase domestic supply, since these ventures may not be competitive in a free market against low-cost timber imports. The effect of the policy-driven supply contraction was to make Australia more dependent on timber imports.

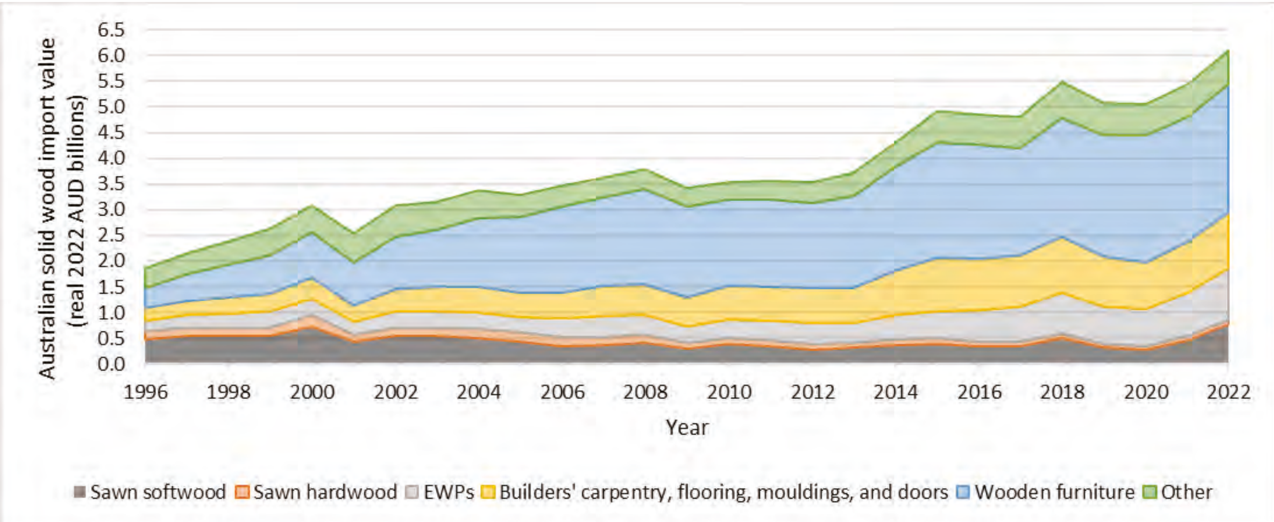
In Figure 5.2 panel (b), the timber market is originally at the free trade equilibrium point E, at the world timber price pw and quantity q4. Thus, Australia is importing q4 – ds1 m^3 of timber and producing ds1 m^3 domestically. The autarky (no trade) equilibrium at p1, q1 is labelled for reference. If the demand for timber increases because of population growth or government incentives that expand house construction, the demand curve will shift from D1 to D2. The market equilibrium will shift from point E to point F, at price pw and quantity traded q5. There is limited incentive to expand domestic production because Australian producers are manufacturing all they can at a price point competitive with the free-market world price for timber. Domestic production stays at ds1 and imports rise to q5 – ds1. The effect of macroeconomic growth or a change in housing policy that increases demand for new houses was to make Australia more dependent on timber imports.

5.2 Australia's Solid Wood Imports

Figure 5.3 illustrates the real (net of inflation) 2022 Australian dollar value of solid wood imports from 1996-97 to 2022-23, which increased 226% over the period to $6.1 billion in 2022-23. In the early 2020s, the most important product categories by value were wooden furniture (44%) and builders' carpentry (19%).

Figure 5.4 indicates that import volume increased 138% over the same period to 7.0 M m^3 RWE in 2022-23, with imports averaging 5.86 M m^3 RWE/y over the period 2018-19 to 2022-23. Notably, sawn softwood imports were relatively static, sawn hardwood imports declined, and all other import categories increased substantially in volume over time. The largest imported product classes by RWE volume in the early 2020s were sawn softwood (35%) and EWPs (30%).

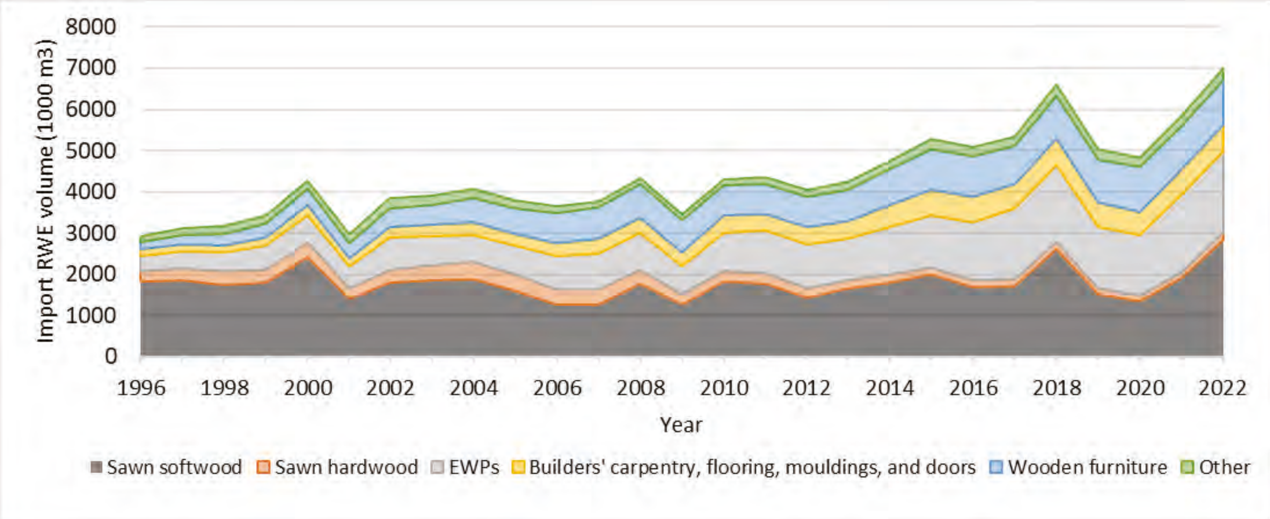
Figure 5.3. Australia's solid wood imports 1996-97 to 2022-23 in real (adjusted for inflation) 2022 Australian dollars



Sources: ABARES (2024a) and ABS (2024a).

The high import volumes are consistent with estimated demand (apparent consumption) at 18 to 20 M m^3 RWE/y and domestic supply at 12.3 M m^3 RWE/y, as described in Chapters 2 and 3. Therefore, imported solid wood accounted for about 35% of all solid wood traded in Australia over the period 2018-19 to 2022-23. In contrast, in the mid-1990s imports accounted for 24% of traded wood (ABARES, 2024b; ABS, 2024a; ABARES, 2025c). Thus, Australia's import dependency has increased by 46% since the mid-1990s.

Figure 5.4. Australia's solid wood imports 1996-97 to 2022-23 in volume (1000s m^3 RWE)



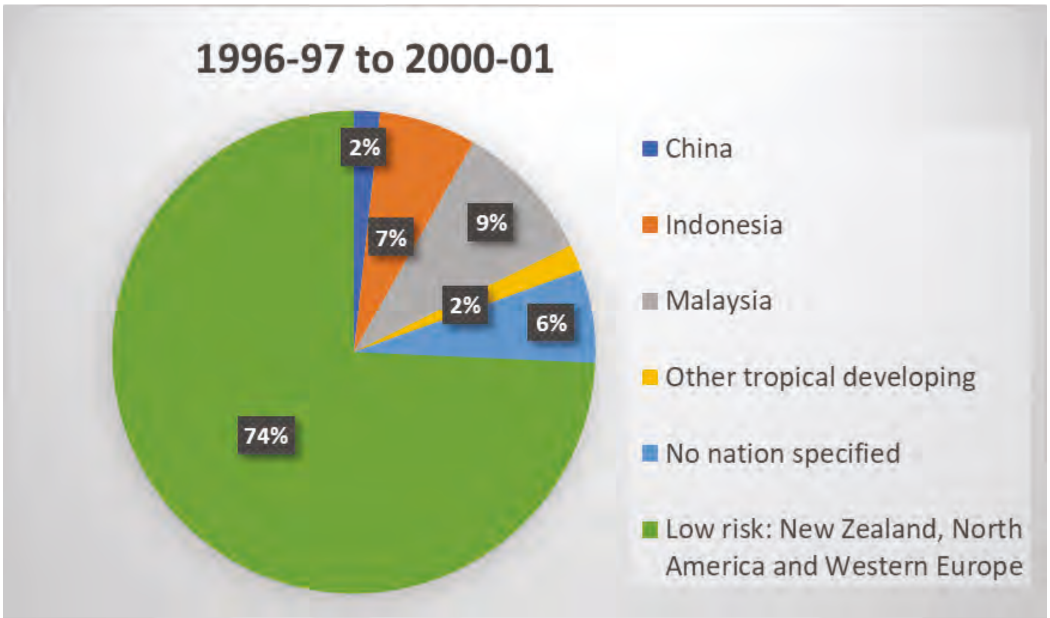
Note: See Appendix A.1.3 for methods for estimation of roundwood equivalent (RWE) volumes.
Sources: ABARES (2024a) and ABS (2024a).

Figures 5.5 and 5.6 report the country of origin and country groupings for Australia's aggregate solid wood imports for the period 1996-97 to 2000-01 and 2018-19 to 2022-23 (ABARES, 2024a). The Global Illegal Logging and Associated Trade (ILAT) Risk Data Tool (https://www.forest-trends.org/idat/) published by Forest Trends was used to identify Australian timber supply chains with elevated-risk (see the definition of elevated-risk imported timber). Australian imports from lower-risk nations and regions, including New Zealand, North America and Western Europe, are illustrated together. Elevated-risk nations are reported individually and in an 'other tropical developing' category. The proportion of solid wood imports from elevated-risk nations doubled between the two periods, with China becoming the dominant supplier of wood products to Australia.

Figure 5.7 reports the proportion of imported wood product volume by product class and country of origin or country groupings (ABARES, 2024a). Most of Australia's imported supply of sawn softwood (*SSM*) comes from developed countries with lower-risk profiles. All solid wood import categories except sawn softwood (*AMESS*) are dominated by developing countries and China, with elevated risk.

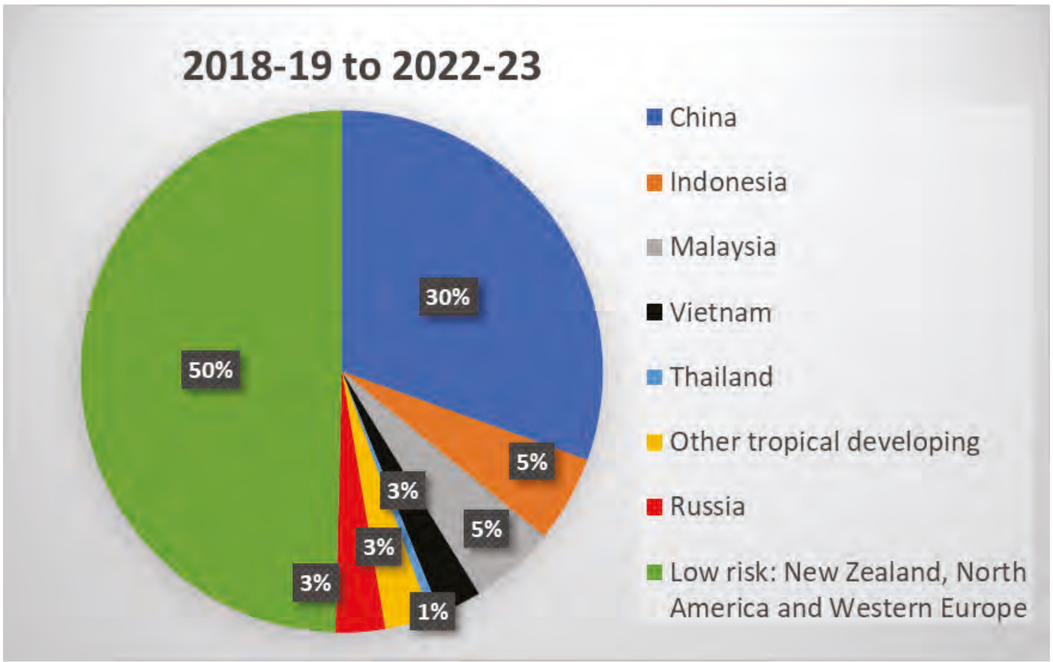
Figure 5.8 summarises import volumes in roundwood equivalent (RWE) by ILAT risk ratings for the periods 1996-97 to 2000-01 and 2018-19 to 2022-23 for the two groupings of imports *SSM* and *AMESS*. Annual total imports averaged 3.44 M m^3 RWE/y in the earlier period, with 74% supplied from lower-risk countries. By 2018-19 to 2022-23, mean annual import volume had increased by 70% to 5.86 M m^3 RWE/y. *SSM* consumption grew 0.13 M m^3 RWE/y relative to 2000-01, with 81.8% of the increase supplied by elevated risk countries, principally Russia and Romania. *AMESS* imports grew by 2.51 M m^3 RWE/y relative to 2000-01, with elevated-risk countries supplying 86.8% of the increase.

Figure 5.5. Proportion of solid wood imports by country or region of origin, 1996-97 to 2000-01



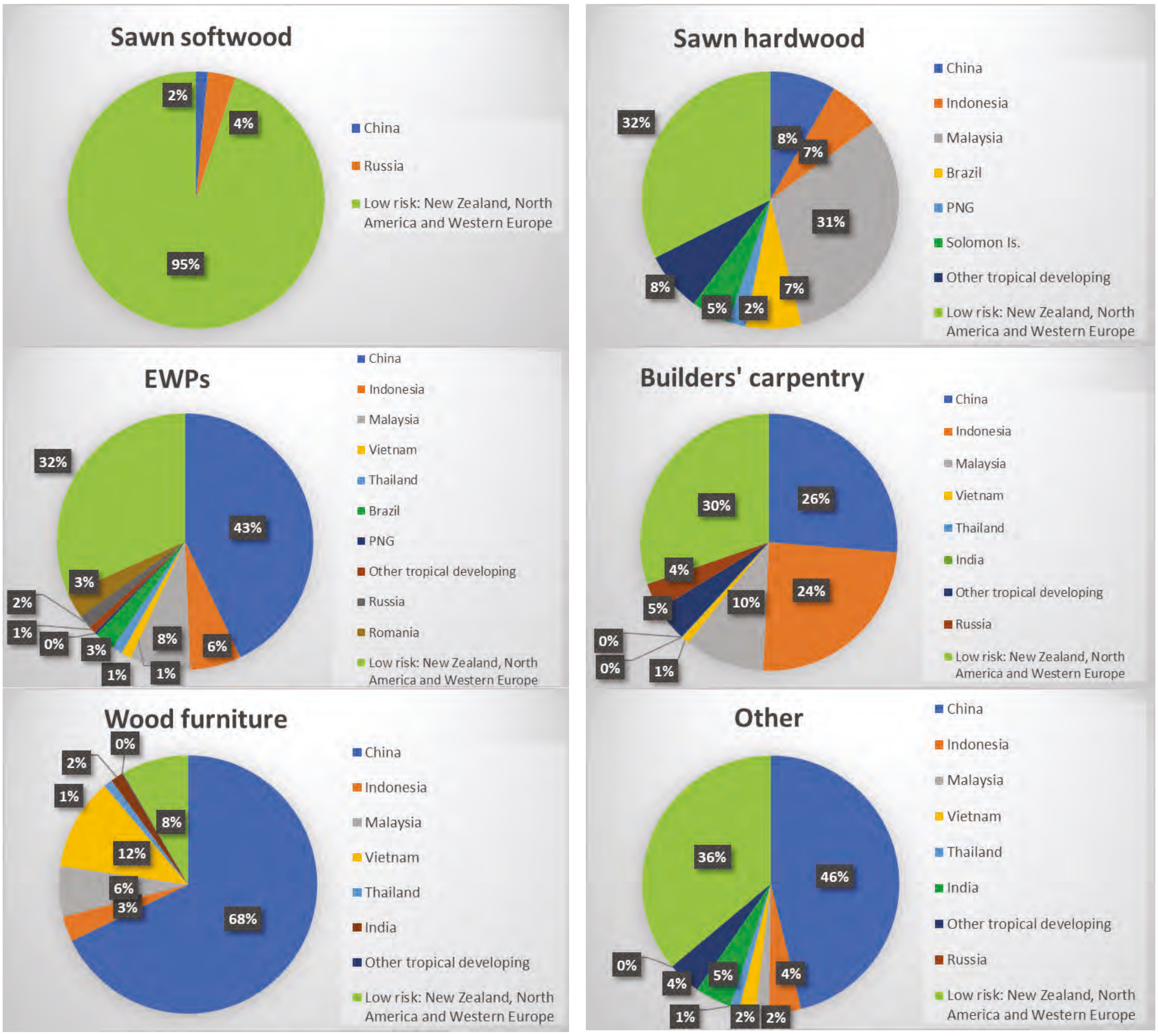
Sources: ABARES (2024a) and ABS (2024a) intersected with the Forest Trends' Global Illegal Logging and Associated Trade (ILAT) Risk Tool (https://www.forest-trends.org/idat/).

Figure 5.6. Proportion of solid wood imports by country or region of origin, 2018-19 to 2022-23



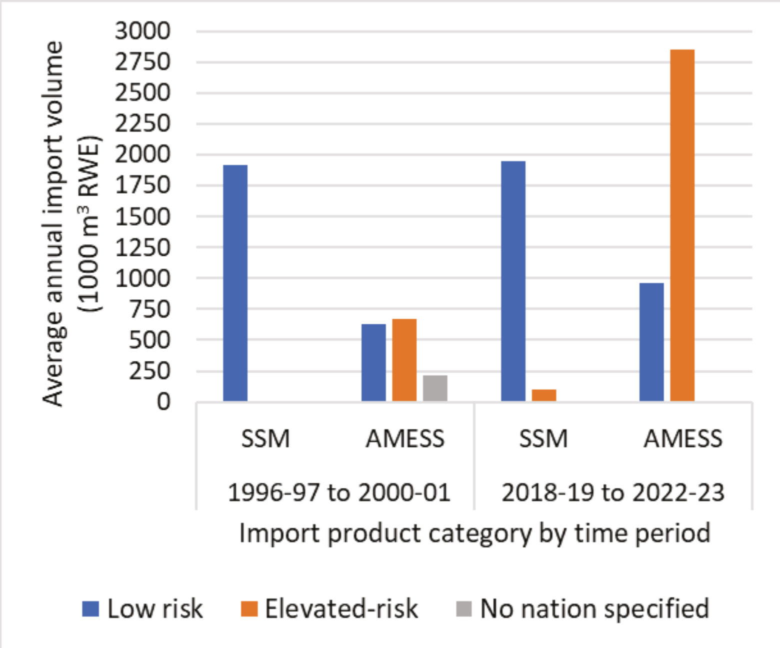
Sources: ABARES (2024a) and ABS (2024a) intersected with the Forest Trends' Global Illegal Logging and Associated Trade (ILAT) Risk Tool (https://www.forest-trends.org/idat/).

Figure 5.7. Proportion of wood product category import volume supplied by country or country groupings, 2018-19 to 2022-23



Sources: ABARES (2024a) and ABS (2024a) intersected with the Forest Trends' Global Illegal Logging and Associated Trade (ILAT) Risk Tool (https://www.forest-trends.org/idat/).

Figure 5.8. Australia's mean annual sawn softwood imports (*SSM*) and all solid wood imports except sawn softwood (*AMESS*) by ILAT risk, 1996-97 to 2000-01 and 2018-19 to 2022-23



Note: See Appendix A.1.3 for methods for estimation of roundwood equivalent (RWE) volumes.
Sources: Intersection of Australian trade data by country of origin (ABARES, 2024a; ABS, 2024a) with risk from Forest Trends' Global Illegal Logging and Associated Trade (ILAT) Risk Tool (https://www.forest-trends.org/idat/).

5.2.1 Materials Footprint of Timber Trade with China

Preliminary analysis of Australia's import volume revealed China's share of Australia's solid wood imports had increased from 2% (mean 1996-97 to 2000-01) to 30% (mean 2018-19 to 2022-23) during the study period. ILAT classifies China as higher-risk; however, the precise country of origin of individual wood product units exported from China is obscured by China's role as a resource aggregator and global processing hub, where export-focussed wood product manufacturers rely on imported feedstock (Ke et al., 2019; Zhang and Chen, 2021) that are mixed during production with limited traceability (Forest Trends, 2021; Richards et al., 2022; Ke et al., 2024). To improve understanding of Australia's global materials footprint, an analysis of China's solid wood product supply chain was performed with official China government import and export statistics (2018 to 2023) available from General Administration of Customs of the People's Republic of China (http://stats.customs.gov.cn). Statistics were compiled separately for each of China's wood product processing provinces.

China's import volume to each province by level of pre-processing (i.e. logs, sawn timber, veneer and EWPs), wood type (i.e. softwood, tropical hardwood and temperate hardwood) and country of origin were extracted from the database and converted to RWE volumes with international region-specific conversion factors published by FAO et al. (2020). These import volumes were then assigned an ILAT risk. To estimate country of origin of exported wood products from China, it was assumed that inter-province flow of imported wood within China was negligible;

products manufactured in a processing province were manufactured from the imported resource to that province.

Rule sets were developed to determine which types of pre-processed feedstocks could be used to manufacture particular wood products. For example, wood decking can be produced from logs or sawn timber only. Furniture can be produced from logs, sawn timber, veneer or EWP imports. Descriptions of China's exports to Australia from each processing province were available and clearly categorised 33% of wood product exports to Australia by wood type – softwood, tropical hardwood or temperate hardwood. A further 32% of exports indicated the product was hardwood, but not whether the hardwood was tropical or temperate. Finally, 35% of exports were not clear about whether the wood was softwood or hardwood, with 70% of this volume in furniture exports.

Countries of origin of wood products exported to Australia from each processing province were estimated in proportion to the supply of the appropriate wood type in the appropriate pre-processed condition to the province of manufacture. For example, the materials footprint of 100 m^3 RWE tropical hardwood decking manufactured in a processing province where 65% of the tropical hardwood was imported from Malaysia, with 20% in log or sawn timber form, and 35% was imported from Papua New Guinea, with all volume in log or sawn timber form, would be estimated as 13 m^3 from Malaysia (100*0.65*0.2) and the remainder from Papua New Guinea. For exported products where type of hardwood was unclear, country of origin of the product was estimated in proportion with the imported feedstock from all nations supplying appropriately pre-processed temperate and tropical hardwoods to that processing province. When exported products provided no information about wood type, country of origin was assigned in proportion to all suppliers of appropriately pre-processed coniferous, temperate hardwood and tropical hardwood to that processing province. RWE volumes of all wood products exported to Australia from all processing provinces were summed by country of origin and ILAT risk.

Analysis of China's solid wood product supply chain revealed China's imports for 2018 to 2023 averaged 115.9 M m^3 RWE/y (Figure 5.9, panel a), which is consistent with the FAO (2024a) estimate in 2023 of 118 M m^3 RWE. China's imports were dominated by softwoods (68.8%), with tropical and temperate hardwoods accounting for 19.4% and 11.8%, respectively. Elevated-risk countries of origin accounted for 61.3% of the total, including Russian timber (29.6%), and all tropical hardwood imports (19.4%). Goods destined for Australia (1.79 M m^3 RWE/y) were manufactured in processing provinces with less exposure to elevated-risk wood than the China average. About 43.9% of exports to Australia (0.78 M m^3 RWE/y; Figure 5.9, panel b) were elevated-risk, notably dominated by all imports except sawn softwood (*AMESS*) which used substantial volumes of hardwoods. Consequently, China's exports to Australia have higher proportions of tropical (27.4%) and temperate (17.5%) hardwoods than China's import mix.

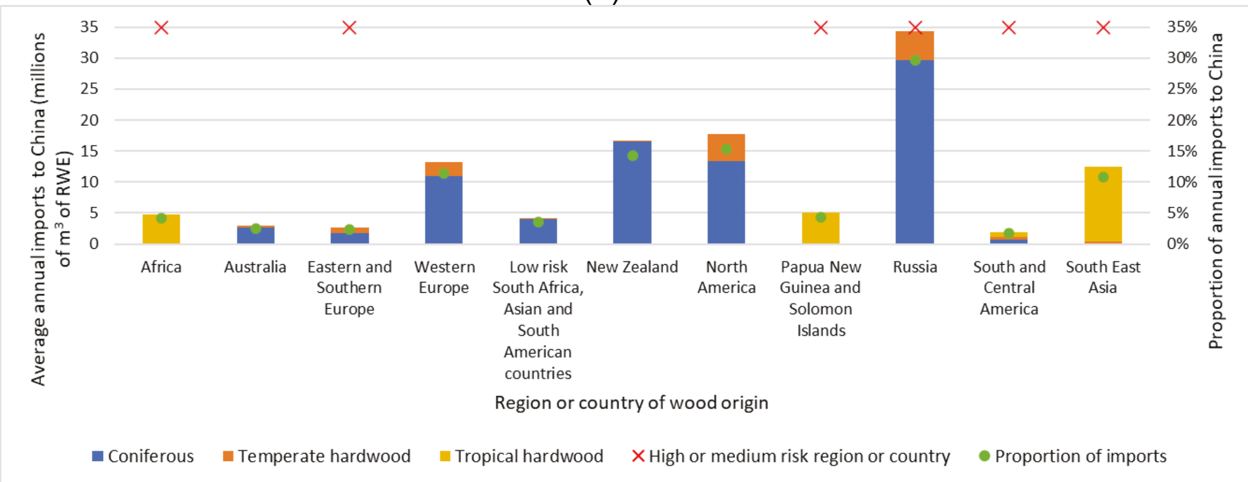
5.2.2 Australia's Imports from Elevated-risk Timber Harvesting Hotspots

Australia's mean annual (2018-19 to 2022-23) bilateral (red arcs) and multilateral (purple arcs via China) elevated-risk imports are illustrated Figure 5.10. They sum to 1.95 M m^3 RWE/y, with dominant suppliers including Russia for softwood products

(16%), and hardwood products from Indonesia (16%), Malaysia (16%), Vietnam (10%), Papua New Guinea and the Solomon Islands (9%), and African nations (8%). Australia's annual consumption of timber from elevated-risk nations over this period was double the total harvest volume from Australia's public and private native forests in 2022-23.

Figure 5.9. China's average annual (a) solid wood imports and (b) exports to Australia (2018 to 2023)

(a)



(b)

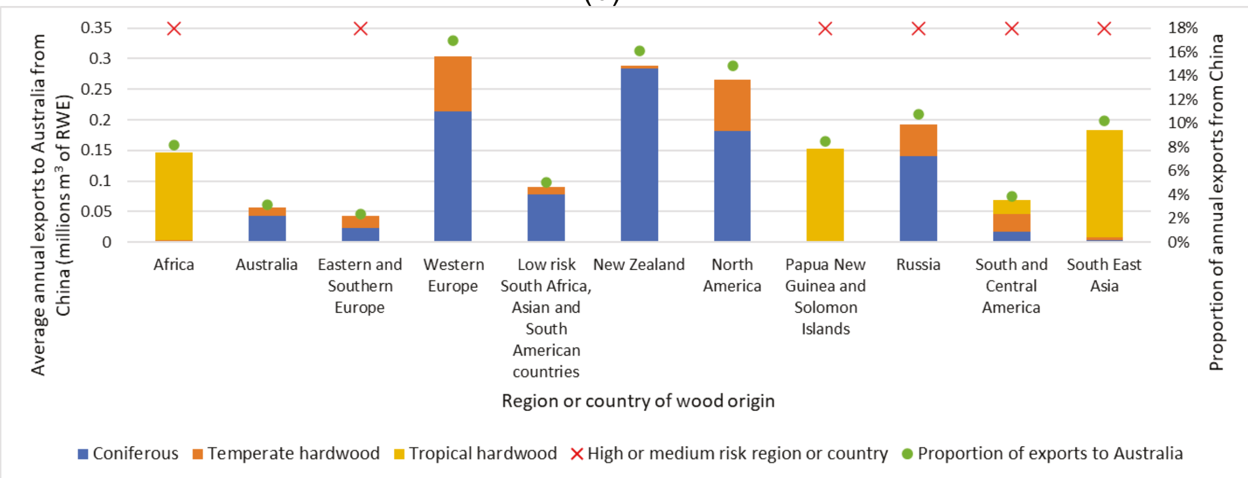
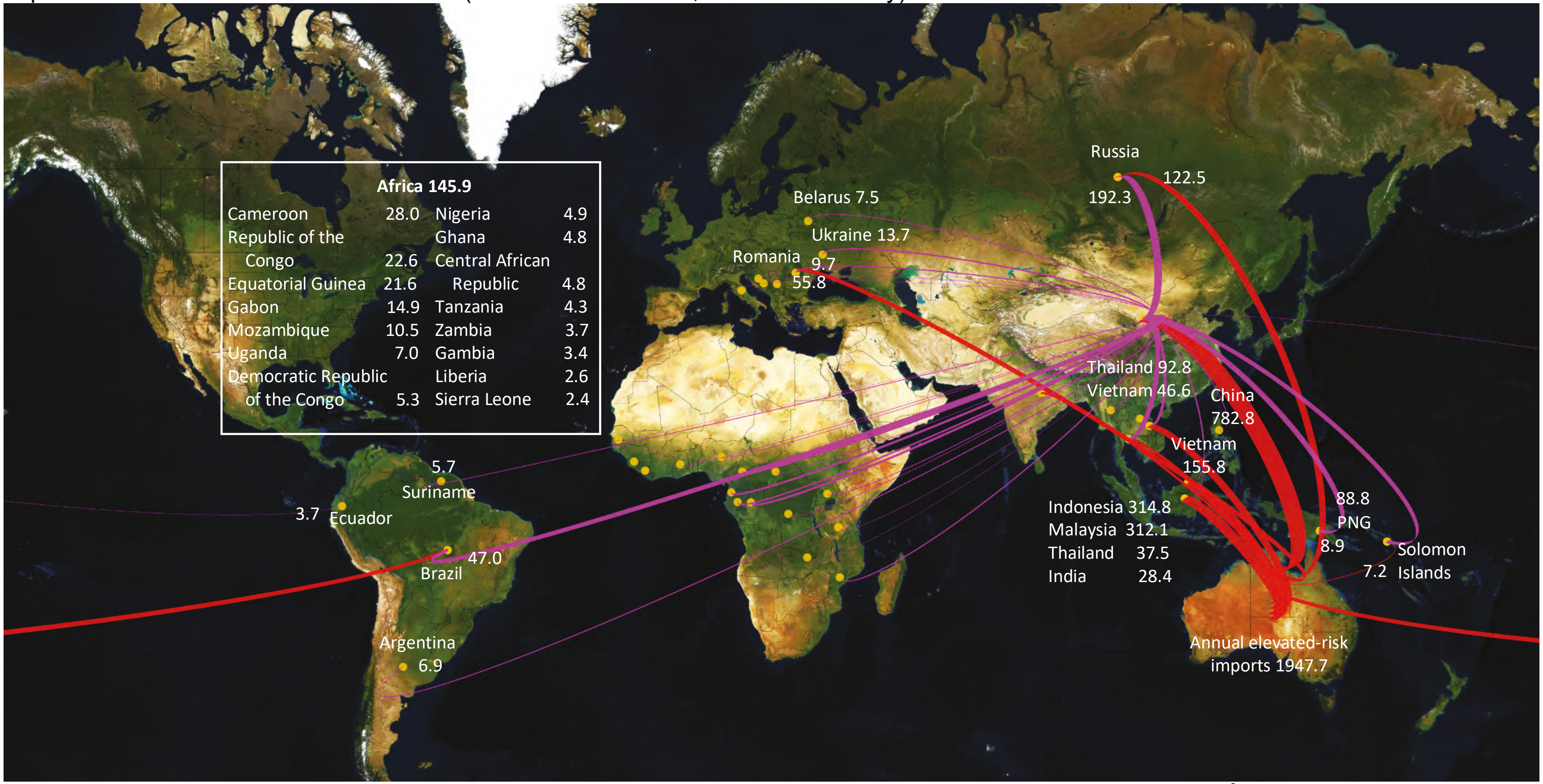


Figure 5.10. Australia's mean annual bilateral demand (red arcs) and multilateral derived demand via China (purple arcs) for solid wood imports from countries with elevated-risk (2018-19 to 2022-23, 1000s m³ RWE/y)



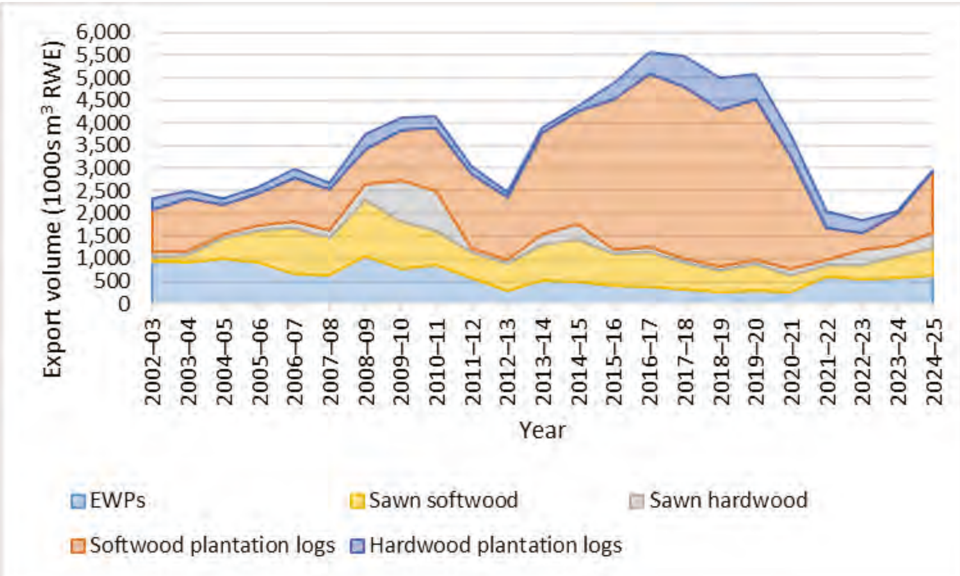
Note: Mapped trade flows commencing at a yellow circle were limited to nations from which Australia directly or indirectly procured at least 2000 m³ RWE/y (2018-19 to 2022-23). The magnitude of selected trade flows have been labelled. PNG is Papua New Guinea. The sum of the purple arcs is equal to the 782,800 m³ RWE/y imported to Australia from China. From 2022, sanctions were placed on Australia's bilateral timber trade with Russia. Trade flow arcs were visualised with the open-source geospatial analysis tool, Kepler.gl (https://kepler.gl/demo) with a square root scale factor (i.e. 250,000 m³ RWE/y is five times thicker than 10,000 m³ RWE/y).

5.3 Australia's Solid Wood Exports

Figure 5.11 reveals that Australian solid wood exports varied substantially over the period 2002-03 to 2022-23, but averaged 3.57 M m^3 RWE/y. Most of the volatility was due to exported softwood and hardwood plantation logs (i.e. unprocessed solid wood), which accounted for 59% of all exported solid wood volume throughout the period. There was controversy over the high levels of softwood plantation log exports in the 2010s, particularly about whether these exports included sawlog volume that could have been utilised domestically (FWPA, 2020).

The volume of exported processed solid wood products was relatively steady throughout the period. The source of the relatively large volume of sawn hardwood reported as exported around 2008 to 2011 (>600,000 m^3 RWE/y) during a time of rapidly declining native forest harvest volume is unclear.

Figure 5.11. Australian export volume (RWE) of solid wood products 2002-03 to 2024-25



Note: See Appendix A.1.3 for methods for estimation of roundwood equivalent (RWE) volumes. Softwood and hardwood plantation log volume is RWE volume.
Source: ABARES (2025c).

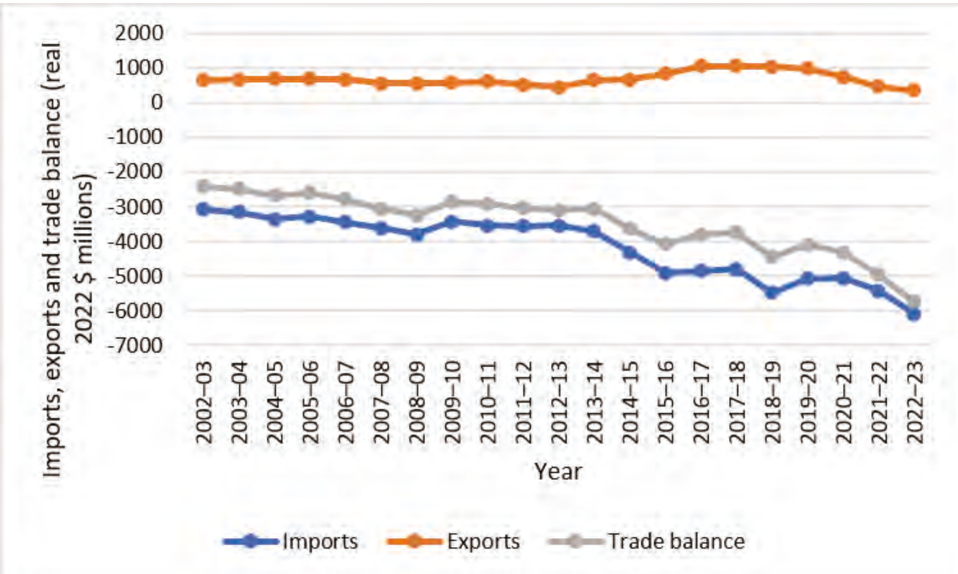
Assuming all sawn hardwood is native forest hardwood and that, consistent with domestic EWP production data (ABARES, 2025c), 1.9% of exported EWPs utilise native forest logs, then total native forest exported volume averaged about 228,000 m^3 RWE/y or 6.4% of export volume. Therefore, about 93.6% of exported solid wood volume in Figure 5.11 was from softwood and hardwood plantations.

5.4 Australia's Timber Trade Deficit

According to ABARES (2025c) data illustrated in Figure 5.12, the value of Australia's solid wood exports averaged \$570 M/y in real (inflation adjusted) 2022 Australian dollars over the period 2002-03 to 2022-23, earning Australia a return of \$160/m^3 RWE (\$570 M / 3.57 M m^3). Solid wood import volume averaged 4.64 M m^3 RWE/y over the period 2002-03 to 2022-23 (Figure 5.4), and the average solid wood import value in real 2022 Australian dollars was \$4171 M/y (Figure 5.3), indicating the average cost of Australia's timber imports was \$899/m^3 RWE. Therefore, Australia's solid wood imports have been 5.6 times more valuable per cubic metre than Australia's solid wood exports. This reflects a disparity in value adding, with Australia importing substantial quantities of high-value wood furniture and builders' carpentry, compared to exports that have been dominated by unprocessed logs.

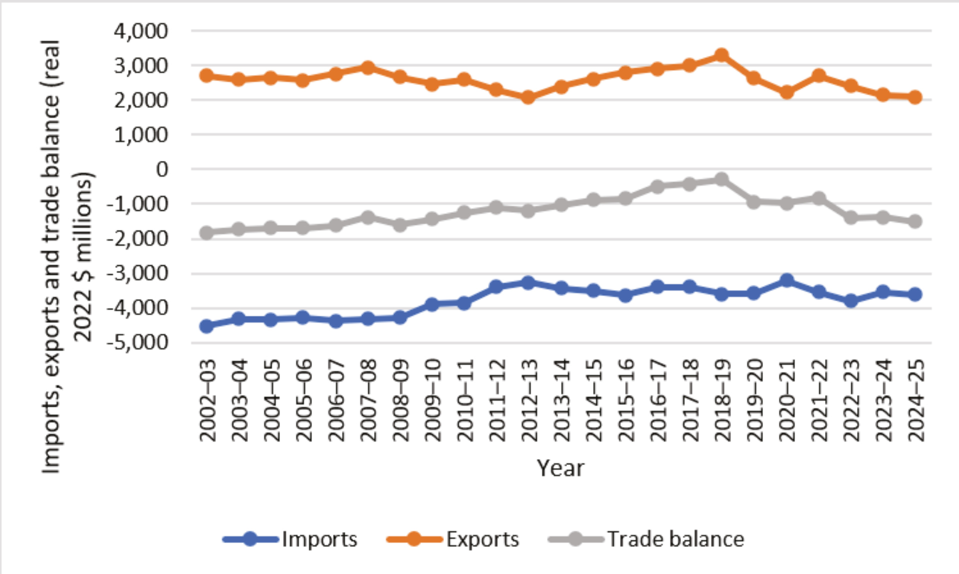
In 2022-23, Australia's trade deficit in solid wood products was \$5.7 billion (Figure 5.12), the result of \$6.1 billion in imports versus \$0.35 billion in exports. For completeness, Figure 5.13 reports Australia's trade in paper, pulp and woodchip, revealing a trade deficit of \$1.4 billion in 2022-23, arising from \$3.8 billion in imports and \$2.4 billion in exports. Therefore, Australia's total trade deficit in forest and wood products was \$7.1 billion in 2022-23. This is considerably higher than the trade deficit reported by ABARES (2024b) in 2022-23 of \$4.1 billion because their summary excluded the \$2.5 billion in wooden furniture imports, and it seems a fraction of miscellaneous 'other' wood imports was also excluded.

Figure 5.12. Australia's trade balance in solid wood products in millions of real (inflation-adjusted) 2022 dollars



Source: Export data from ABARES (2025c) and accounts for hardwood and softwood logs, hardwood and softwood roughsawn and dressed timber, engineered wood products and miscellaneous wood products, including builders' carpentry. Wood furniture export value was not readily available, but likely to be small in quantity and value. Import data was from ABARES (2024a), with wood furniture imports from ABS (2024a).

Figure 5.13. Australia's trade balance in paper, pulp and woodchip in millions of real (inflation-adjusted) 2022 dollars



Source: ABARES (2025c).

5.5 Domestic Economy Impacts of Rising Dependence on Imports from Elevated-risk Jurisdictions

Increased dependence on timber imports since the mid-1990s has increased the Australian construction sector's exposure to international timber market volatility and challenges with international shipping logistics. Both problems were experienced between 2019 and 2022, resulting in reduced import quantity and higher domestic (and world) timber prices, which coincided with a considerable reduction in domestic housing commencements. For example, there were 220,000 housing commencements per annum in 2017-18 and 2018-19, but only 175,000 housing commencements per annum in 2019-20 and 2020-21 (see Figure 6.1) (ABS, 2024b). Achieving Australia's house construction targets announced by Federal and State governments in recent years is dependent on access to imported wood. With Australia's declining sovereign capacity in wood products, Woods and Houghton (2022) projected rising volatility in Australia's timber market in the future, with the potential for substantial disruptions to residential construction.

Short-term market volatility damages the economy but is unlikely to be sufficient on its own to incentivise long-term private sector investments in Australia to increase domestic sawlog production and mill processing capacity. This is because when the market shock has passed, the Australian forest and wood products sector must again compete with low-cost imported timber produced in jurisdictions with environmental and social impacts that are unacceptable within Australia. Consequently, profit margins for Australian growers and wood product manufacturers are tight and private investors will seek higher rates of return elsewhere in the economy.

6. Australia's Timber Harvest Leakage into International Elevated-Risk Harvesting Hotspots

This chapter presents the first multi-decade *ex-post* analysis of international timber harvest leakage, focusing on the impacts of progressive closure of Australia's public native forest estate between 1996 and 2023. While reducing native forest timber harvesting is a key domestic strategy for climate risk mitigation and biodiversity conservation, it can inadvertently trigger market leakage – displacing environmental impacts to other jurisdictions. Analysis with a Vector Error Correction Model (VECM) and using the Global Illegal Logging and Associated Trade (ILAT) Risk Tool identified reduced domestic native forest harvesting as a structural driver of Australia's growing import dependency, with timber harvest leakage at 81.3%. Critically, 86.8% of the displaced demand was met by wood sourced from nations assessed by ILAT as having elevated-risk profiles, including in Southeast Asia and Africa's Congo Basin. In 2022-23, Australians consumed twice as much imported elevated-risk timber as was produced from domestic public and private native forests. These findings demonstrate that reducing native forest harvesting may have counterproductive consequences for carbon emissions and biodiversity conservation at regional and global scales.

6.1 Introduction

The important role of forests in providing renewable construction materials, carbon sequestration, biodiversity conservation and cultural and recreation benefits can result in conflicting management priorities (Hellström, 1999; Furness et al., 2015; Venn, 2023). Well-intentioned restrictions on timber harvesting have emerged globally as a core domestic policy for meeting near-term climate and biodiversity conservation targets. However, interventions that inadequately consider or ignore leakage can threaten global action to achieve the Paris climate and Kunming-Montreal biodiversity targets, as well as undermine the integrity of carbon, biodiversity and other natural capital markets (Dieter et al., 2020; Ford et al., 2020; Fuchs et al., 2020; Schier et al., 2022; Cerullo et al., 2023; Egenolf et al., 2023; Filewod and McCarney, 2023; Kan et al., 2023a; Kumeh and Ramcilovic-Suominen, 2023; Wang et al., 2023; Cabernard et al., 2024; Swinfield et al., 2024; Verhaeghe and Ramcilovic-Suominen, 2024; West et al., 2024; Balmford et al., 2025; Johnston et al., 2025; Lundmark, 2025; Williams et al., 2025; Abman et al., 2026).

Leakage results when a policy that reduces local production causes markets to fill the supply gap by procuring substitutes from elsewhere. Leakage is often categorised into activity and market leakage (Haya et al., 2023). Activity leakage occurs when the reduced harvest project causes mobile factors of production (labour and capital) to relocate to similar activities outside the project area. Market leakage occurs when the project changes incentives for timber harvesting and land management (e.g. native forest clearing to facilitate timber plantation establishment) outside the project area. This paper is focussed on international market leakage.

Global wood markets are large relative to the size of individual reduced forest harvest interventions, wood products are highly substitutable, and demand in developed countries is relatively inelastic with respect to price (Kim et al., 2014; Ingalls et al., 2018; Kallio et al., 2018; Schier et al., 2022; Cerullo et al., 2023; Filewod and McCarney, 2023; Williams et al., 2025). There is growing evidence that implementing reduced forest harvest policies without simultaneous restrictions on consumer demand results in leakage to other forests or substitutes with higher carbon footprints (e.g. steel, concrete, plastic, and carpet). Several studies have used global trade data to attribute timber harvesting (Zhang et al., 2020), forest degradation (Kan et al., 2023b) and native forest clearing for timber plantation establishment (Pendrill et al., 2019a; Pendrill et al., 2019b) to consumer nations, revealing that wealthier nations with increasing forest protections drive forest impacts in poorer nations. This raises legitimate concerns that perceived local benefits from a reduced harvest policy will be substantially offset by increased impacts globally (Gan and McCarl, 2007; Kallio et al., 2018; Hoang and Kanemoto, 2021; Kan et al., 2023b; Balmford et al., 2025). Numerous *ex-ante* studies have tested this theory by simulating the impact of reduced forest harvest policies in Europe, North America and China on timber harvest leakage into domestic and international forests, with findings falling within the range of 42% to 95% (Wear and Murray, 2004; Gan and McCarl, 2007; Nepal et al., 2013; Hu et al., 2014; Kallio et al., 2018; Dieter et al., 2020; Schier et al., 2022; Egenolf et al., 2023; Fischer et al., 2024; Hu et al., 2024; Ter-Mikaelian et al., 2024; Lundmark, 2025). However, there are few *ex-post* econometric evaluations. Indeed, the authors are only aware of the study by Zhang and Chen (2021), who examined the impact of China's native forest timber harvest ban on imports. Their dataset spanned 2002-2018, including four years of data while the ban was being rolled out and one year of data after full implementation (2018).

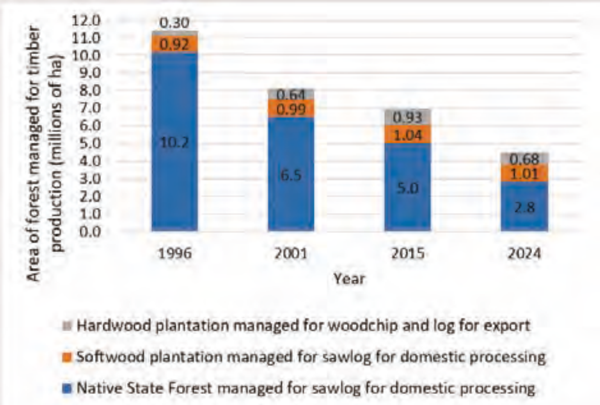
Australia provides a unique opportunity to examine how a developed economy has adjusted to declining sovereign capacity in solid wood production through *ex-post* analysis. Since the mid-1990s, state and federal governments have progressively pursued domestic land sparing forest policies through reduced native forest harvesting (Venn, 2023). As indicated in Figure 6.1, this has substantially reduced the net harvestable area within Australia's State Forests (publicly owned native forests managed for multiple use, including timber production) and national hardwood sawlog supply. Consequently, national aggregate plantation and native forest sawlog production decreased 24% per capita since the mid-1990s (ABARES, 2025c). Details about Australia's forests and wood production are presented in Chapter 3.

In 2025, the NSW State Government announced the transfer of another 176,000 ha of State Forest to the Great Koala National Park (GKNP) (NSW Government, 2025). Funding for management of the GKNP will be generated by the sale of carbon credits from reduced native forest timber harvesting under the Improved Forest Management in Multiple-use Public Native Forests (INFM) Australian Carbon Credit Unit (ACCU) methodology approved in June 2026 (Department of Climate Change Energy the Environment and Water, 2026). INFM defines market leakage of carbon as that associated with displacement of consumer demand to interstate or international forests and sets a maximum allowable market leakage rate of 40% of net abatement (after accounting for other leakage deductions). While the framework provides broad assessment guidelines, independent qualified assessors are responsible for constructing a defensible market rationale for market leakage on a project-by-project basis.

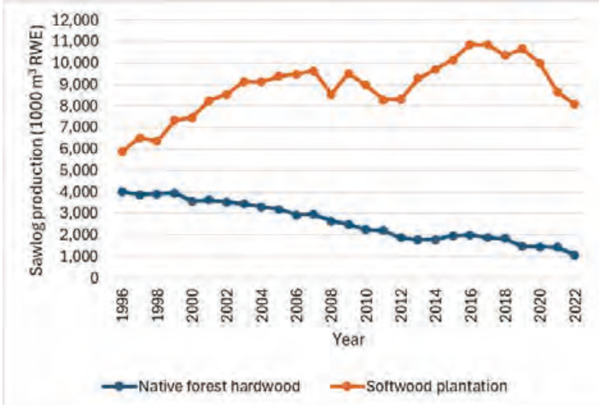
Given the paucity of ex-post studies, the Australian experience serves as a critical benchmark analysis for nations where forest protection from timber harvest inadvertently risks outsourcing carbon emissions and biodiversity loss. Following Wiedmann et al. (2015), the analysis employed a materials footprint approach that converted all solid wood product flows into cubic metres of roundwood equivalent (RWE, i.e. log volume) and allocated resource extraction to the final user. A Vector Error Correction Model (VECM) was fitted to data that defined the materials balance of Australia's solid wood market[2]. Data for the model are summarised in Figure 6.1, comprising supply from sawn softwood imports (*SSM*), all solid wood imports except sawn softwood (*AMESS*), native forest sawlog production (*NP*) and softwood plantation sawlog production (*SP*), and demand for wood consisting of softwood

Figure 6.1. Time series data defining the materials balance in Australia's solid wood market.

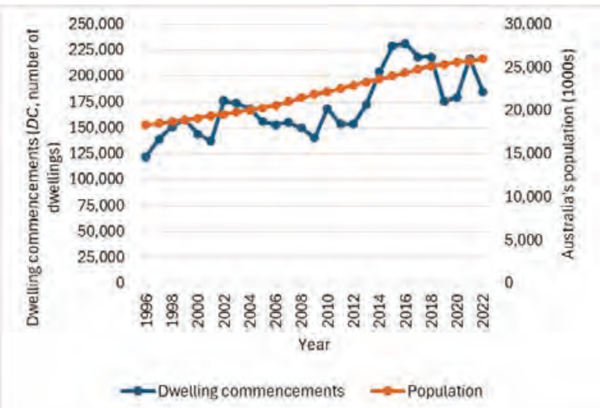
(a) Net harvestable area of multiple use public native forest, and area of public and private timber plantation



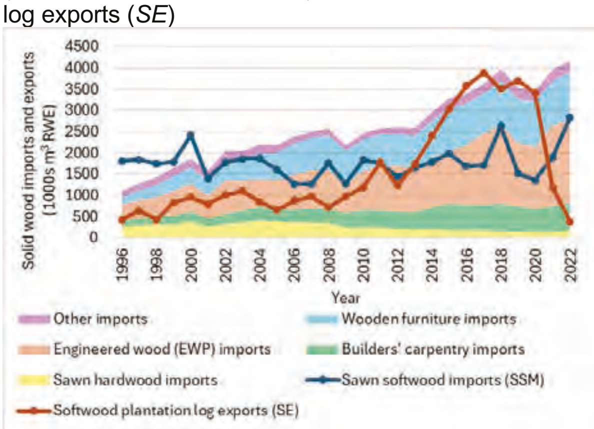
(b) Domestic sawlog production by source: native forest hardwood (*NP*) and softwood plantation (*SP*)



(c) Dwelling commencements (*DC*) and national population



(d) Roundwood equivalent imports and exports: sawn softwood imports (*SSM*), all other solid wood imports (*AMESS*; stacked area chart), and softwood plantation log exports (*SE*)



Note: See Appendix A.1.3 for methods for estimation of roundwood equivalent (RWE) volumes.
Sources: (National Forest Inventory, 1998; Venn, 2023; ABARES, 2024b, 2024a; ABS, 2024a, 2024b; Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2024).

[2] A separate analysis could examine Australia's structurally distinct market for paper products. Supplementary materials justify exclusion of pulplogs from the solid wood product analysis.

plantation log exports (*SE*) and dwelling commencements (*DC*; number of dwellings). The model estimated the cointegrating vector that defines the long-run materials balance (β), as well as the loading coefficients that capture the adjustment behaviour of market participants to shocks (α). Countries of origin of imports were examined against the Global Illegal Logging and Associated Trade (ILAT) Risk Data Tool (https://www.forest-trends.org/idat/) published by Forest Trends, to estimate the level of elevated-risk in Australian supply chains. With preliminary analysis revealing China as the dominant solid wood supplier to Australia, China's supply chain was also investigated to better understand Australia's multilateral forest footprint. Within this framework, the study tested five nested hypotheses for the period 1996-97 to 2022-23.

H1 (Market Equilibrium): A long-run cointegrated relationship exists between supply and demand of solid wood, with imports functioning as a mechanism for reconciling domestic supply deficits to maintain the materials balance.

H2 (Imperfect Substitution): Within the Australian market, plantation softwoods and native forest hardwoods are complementary goods rather than substitutes. Consequently, the existing domestic plantation estate has not mitigated contractions in native forest production.

H3 (Import Dependency): Due to substitution constraints, reduced native forest harvesting has caused a persistent structural shift toward import-dependency, where the majority of the reduced harvest has been substituted with imports.

H4 (Illegality Risk): The growth in Australia's timber import portfolio has been characterized by a disproportionate reliance on timber from high- and medium-risk (hereafter elevated-risk) countries.

H5 (The Conservation Paradox): Reduced native forest harvesting in Australia has produced the unintended consequence of increasing reliance on environmentally riskier supply chains, which undermines global efforts to mitigate the climate and extinction crises.

This study suggests developed nations should be cautious about claiming net global climate and biodiversity conservation benefits from reduced harvest policies that rely on imports to restore the domestic materials balance.

6.2 Results of VECM and ILAT Analysis

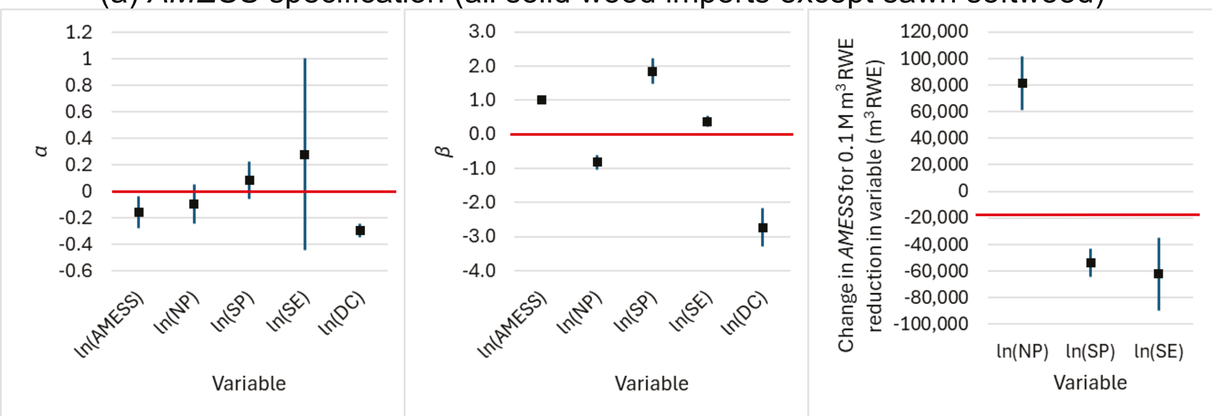
A detailed description of the research methods is presented in Section 6.5. Figure 6.2 illustrates the mean and 95% confidence intervals for loading (α) and long-run materials balance coefficients (β), as well as the long-run change in import volume for a 100,000 m^3 RWE reduction in *NP*, *SP* and *SE* for the disaggregated market VECM specifications – all solid wood imports except sawn softwood (*AMESS*) and sawn softwood imports (*SSM*). Significant results do not intersect zero, and guidelines for their interpretation are provided in the methods. A complete description of datasets, systems of equations, model diagnostic tests and omitted variable tests are provided in the Appendices A.1 to A.3. In brief, the *AMESS* specification passed all model diagnostic tests, confirming the cointegration of supply and demand (i.e. market participants respond to disequilibria to restore the materials balance), and that coefficients are unbiased and economically robust, providing a sound basis for estimating long-run impacts of forest policy and timber supply-chain dependencies. The *SSM* specification passed six of the eight diagnostic tests, revealing a weaker cointegration and unbiased coefficients. The signs of significant *SSM* coefficients can be interpreted with confidence; however, magnitudes should be interpreted cautiously. Due to market aggregation bias, the aggregate imports (*M* = *AMESS* + *SSM*) model specification was not reconcilable with the disaggregated specifications and results have been confined to appendices.

6.2.1 VECM Evaluation of Research Hypotheses 1 to 3

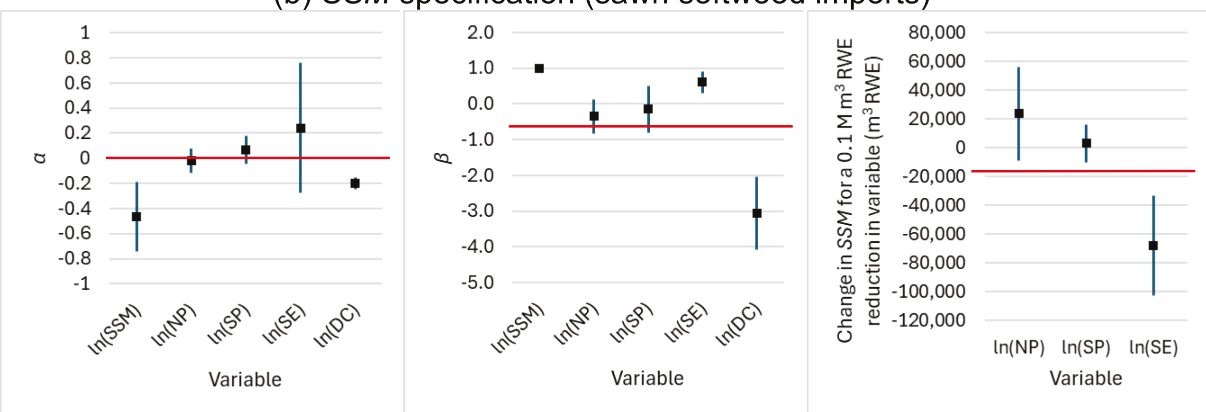
The insignificant $\alpha_{NP}$and α_{SP} across both VECM specifications in Figure 6.2 identify native forest and softwood plantation sawlog production as weakly exogenous, indicating non-responsiveness to timber market shocks. This statistically invalidates an argument that fluctuations in domestic native forest and softwood plantation sawlog supply have been timber market driven. In contrast, the significant and negative α_{AMESS}, α_{SSM} and α_{DC} confirm that imports and dwelling commencements

Figure 6.2. Mean and 95% confidence intervals for VECM α and β coefficients, and the long-run change in imports for a one-time 100,000 m^3 RWE reduction in *NP*, *SP* and *SE* for the (a) *AMESS* and (b) *SSM* specifications

(a) *AMESS* specification (all solid wood imports except sawn softwood)



(b) *SSM* specification (sawn softwood imports)



Note: Following standard VECM reporting protocols (Johansen and Juselius, 1990), the β coefficients have been sign corrected to reflect their directional impact on imports.

act as 'adjusters' to restore the timber market equilibrium. Weakly exogenous variables with significant β coefficients are long-run structural forcing variables that drive the timber market equilibrium without responding to market imbalances (Granger and Lin, 1995; Pesaran et al., 2004). This role is confirmed for native forest sawlog production within the *AMESS* specification, which aligns with the documented historic record of state-mandated native forest shutdowns. Policy-driven native forest harvest reductions force compensatory adjustments in timber imports and construction activity to restore the long-run materials balance. This causal mechanism is not confounded by baseline macroeconomic drift, as such trends are explicitly accounted for by the model's constants. Furthermore, omitted variable bias tests for the Australian-to-US dollar exchange rate and the relative price competitiveness of domestic wood products versus *AMESS* provide no statistical support for the hypothesis that these international market factors are primary drivers of import growth (see Appendix A.3). Therefore, research Hypothesis 1 is supported: import volumes function as a necessary adjustment mechanism to reconcile structural domestic timber supply deficits.

In the *AMESS* specification, the negative β_{NP} confirms that *AMESS* have been a direct long-run substitute for native forest hardwood production. Conversely, the positive β_{SP} indicates that plantation softwoods are complementary (i.e. consumed together) with *AMESS*. Through transitive analysis of the cointegrating coefficients, it is evident that plantation softwoods are not interchangeable with native forest hardwoods; they are joint inputs to the construction sector. This narrative is also supported by the insignificant β_{NP} in the *SSM* VECM specification – changes in native forest hardwood volumes do not affect sawn softwood imports. Furthermore, the short-run dwelling commencement equation in the *AMESS* and *SSM* specifications indicate both native forest hardwoods (or *AMESS*) and domestic plantation softwoods (or *SSM*) must increase for building sector expansion (see Appendix A.2). Together, these statistics provide definitive evidence supporting Hypothesis 2: plantation softwoods and native forest hardwoods have functioned as compliments, not substitutes.

The significant and negative β_{NP} in the *AMESS* specification indicates reduced native forest harvesting has structurally increased Australia's long-term reliance on *AMESS*. Building upon confirmation of Hypotheses 1 and 2, the model identifies a structural effect wherein a 100,000 m^3 RWE decrease in native forest hardwood production forces a long-run increase in *AMESS* of 81,300 m^3 RWE (equation 4), representing an international leakage of 81.3% (equation 5). This supports research Hypothesis 3: the majority of the reduced harvest of native forest hardwoods has been substituted with imports.

Additional policy-relevant VECM findings are described in Appendix A.2.6.

6.2.2 Evaluation of research hypotheses 4 and 5 with bilateral and multilateral elevated-risk import analyses

Australian mean annual sawn softwood imports (*SSM*) and all imports except sawn softwood (*AMESS*) by ILAT timber lower-risk and elevated-risk ratings are illustrated in Figure 5.8 for the periods 1996-97 to 2000-01 and 2018-19 to 2022-23, and mapped for the latter period in Figure 5.10. Critically, 81.8% of the increase in *SSM* and 86.8% of the increase in *AMESS* was met by nations with elevated-risk profiles, including in Southeast Asia and the Congo Basin (Figure 5.10). The risk intensity ratio (RIR; equation 8, methods) revealed *AMESS* growth since 2000-01 had 1.5 to 2 times more elevated-risk (depending on treatment of 'no nation specified' data; Figure 5.8) than *AMESS* in the baseline period. Therefore, research Hypothesis 4 is supported: growth in Australia's timber imports has been characterized by a disproportionate reliance on elevated-risk jurisdictions.

Leakage from reduced native forest harvesting to *AMESS* sourced from elevated-risk jurisdictions was 70.6% (81.3% leakage x 86.8%; equation 9 in methods), with the remaining international leakage (10.7%) to lower-risk jurisdictions. Therefore, research Hypothesis 5 is confirmed, with 70.6% of the perceived environmental benefits of reduced native forest harvesting undermined by a shift toward elevated-risk supply chains.

6.3 Discussion

This study provided the first *ex-post* econometric analysis of international timber harvest leakage caused by reduced domestic forest harvest policies where the implementing nation has had decades (1996-97 to 2022-23) to adjust to the new policy environment. The VECM empirically confirmed that reduced native forest harvesting in Australia has precipitated a long-term structural shift in the nation's materials balance toward increasing reliance on imports (H1). As intended by policymakers (Carron, 1985) and described by industry experts (Raison and Nambiar, 2024; ABARES, 2025e, 2025b; Forestry Australia, 2025), Australia's plantation estate was found to complement rather than substitute for native forest hardwoods (H2). Consequently, timber harvest leakage from reduced native forest harvesting into all imports except sawn softwood (*AMESS*) was high, at 81.3% (H3). The structural forcing of the timber market through reduced native forest hardwood supply drove 59% of the growth in imports since the mid-1990s[3]. Domestic supply constraints accounted for the remaining 41% of import growth by failing to keep pace with rising domestic demand. The analysis compares favourably with the scant literature on Australian timber harvest leakage (Section 6.3.1). Preliminary assessment of leakage from reduced native forest harvesting to *AMESS* suggests hardwood timber is used in a large fraction of the growth in imported builders' carpentry, plywood and wood furniture (Appendix A.6).

Crucially and consistent with international studies (Cerullo et al., 2023; Kan et al., 2023a; Kumeh and Ramcilovic-Suominen, 2023), timber harvest leakage from Australia was not geographically neutral; 86.8% of leakage from reduced native forest harvesting to *AMESS* import volume since 2000-01 was sourced from elevated-risk countries (H4 and H5). In 2022-23, Australians consumed two times more timber from elevated-risk nations than was produced from Australia's lower-risk

[3] From Figure 5.4, aggregate import volume increased by 4.06 M m^3 RWE/y between 1996-97 and 2022-23. From Figure 6.1, native forest sawlog production declined 2.93 M m^3 RWE/y between 1996-97 and 2022-23. Reduced native forest timber production leaked into imports at the rate of 81.3%, indicating 2.38 M m^3 RWE/y increase in imports were caused by reduced domestic native forest production. Therefore, reduced native forest hardwood supply drove 59% (2.38 M m^3 RWE/y / 4.06 M m^3 RWE/y) of the growth in imports since the mid-1990s.

public and private native forests, substantially undermining the perceived environmental benefit of reduced domestic timber production. This aligns with the fact that increased global timber harvest volume between 1996 and 2023 was produced entirely by developing countries (FAO, 1999, 2024a). Findings are also compatible with previous studies that have assessed Australia's exposure to elevated-risk timber (see Section 6.3.1).

6.3.1 Comparison of the VECM timber harvest leakage and ILAT analysis with previous Australian timber harvest leakage and illegality risk estimates

There is scant literature against which the international harvest leakage results can be compared; however, an *ex-ante* projection by Gan and McCarl (2007) estimated Australia's international timber harvest leakage would be 89%, with 79% of the leakage transferred to developing countries. Those findings are remarkably similar to the *ex-post* VECM analysis reported here. Studies commissioned by Australia's Federal Government Department of Climate Change and Energy Efficiency asserted that reduced native forest sawlog production in the public estate would have a high- and medium-risk of leakage into private native forests and international forests, respectively (Whittle et al., 2012; Whittle et al., 2013). An ABC television Four Corners investigation revealed the shutdown of Victorian native forestry has resulted in leakage of demand from Victoria into Tasmania's public and private native forest estates (Longbottom et al., 2026).

Daigneault et al. (2025) used the Global Timber Model (GTM) to make *ex-ante* projections of timber harvest and carbon leakage from reduced forest harvest policies by global region for the period 2020 to 2200. Australia was modelled as part of the Oceania region along with New Zealand, Papua New Guinea, the Solomon Islands and other Pacific Island nations. Reduced forest harvesting in native forests in Oceania was found to increase global carbon stocks. However, none of the simulated mechanisms by which carbon sequestration could be increased via reduced domestic native forest harvesting (e.g. domestic plantation expansion for solid wood production, intensification of domestic native and plantation forest management to increase yields, increased use of pulp logs and sawmilling waste in EWP manufacture, and substitution with lower embedded carbon solid wood imports) were implemented in Australia between 1996-97 and 2022-23. Without significant policy change, Australia's future response to further reductions in native forest harvesting would likely mirror the immediate past – increasing dependence on imported timber from elevated-risk countries. It is not clear that the GTM was calibrated to specifically represent Australian forest policy, nor the domestic timber market and rural land sector. Given that the area of Australian native forest that is potentially available for timber production and biophysically capable of producing commercial wood products is about 20 M ha (Davey and Dunn, 2014; Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2024), and New Zealand does not harvest native forests, Australia probably represents about half of the modelled Oceania native forest area. Results were insufficiently disaggregated to inform Australian policy.

The only *ex-post analysis* of Australian native forest leakage was a non-econometric analysis of time series data (1996-97 to 2013-14) by Warman and Nelson (2016).

They argued that the combination of public native forest harvest levels averaging 12% below the allowable sustainable cut, and rising domestic softwood plantation sawlog production constituted evidence of substitution of plantation softwoods for native forest hardwoods. Despite identifying rapidly rising leakage in solid wood products, the authors asserted the increase in net exports driven by plantation pulp logs was evidence of minimal international leakage and global benefits of land sparing policy in Australia. The decision to analyse pulp logs and sawlogs as one market masked the substitution of native forest hardwoods for solid wood imports. The analysis also appears to have incorrectly assumed expanded plantation pulp log production represented causal additionality. Figure 3.11 clearly illustrated the structural decoupling between the native forest sector and the hardwood plantation estate – there is no relationship between native forest pulp log or sawlog production, and hardwood plantation area. Hardwood plantation pulp log volumes represent a counterfactual trend that would have occurred regardless of native forest harvest restrictions, *ceteris paribus*. Therefore, hardwood plantation volumes do not represent a credit to offset leakage from reduced native forest harvest projects.

Imported wood accounted for 35% of all traded solid wood in Australia over the period 2018-19 to 2022-23, with the ILAT risk assessment indicating 50% was sourced from high- and medium-risk countries. This suggests illegality risk associated with 17.5% of solid wood traded in Australia. Incorrect paperwork associated with imports does not prove illegality, but does highlight challenges with timber supply chain traceability. A 2025 report published by the Federal Government Department of Agriculture, Fisheries and Forestry (DAFF) under the Freedom of Information Act, which revealed that 50% (37 out of 74 tests) of sampled imported wood products available at Australian retail were not from the country specified, or not of the species or genus specified, or both (Source Certain, 2025). Product groups and origins of particular concern included plywood manufactured in China; composite products from Southeast Asia such as meranti-faced marine plywood, doors and mouldings; Burmese teak in rough-sawn form and in composite goods such as doors; and Russian plywood and laminated veneer lumber (Source Certain, 2025). Hoisington (2010) asserted the level of illegality (as opposed to risk) in Australian imports was at least 9%. In 2026, the Federal Minister for Forestry indicated a willingness to discuss the Australian timber industry's long-standing recommendation of compulsory country-of-origin labelling in wholesale and retail markets, but that because Australia does not produce enough timber, the government's focus was on keeping timber prices affordable (Broom, 2026).

6.3.2 Carbon credit discount for reduced native forest harvest projects

International carbon accounting rules allocate emissions from production of timber imports to the national accounts of the exporting country. Nevertheless, national accounts reporting in exporting countries does not negate leakage caused by policy shifts in the importing country. For example, had demand for one additional cubic metre of timber in Australia not leaked to Papua New Guinea, the tree at the margin would not have been harvested and emissions outside Australia would have been lower regardless of whether the emissions were tracked in national accounts.

To ensure the atmospheric integrity of domestic abatement claims, international leakage must be accounted for, otherwise high-income countries may simply export their carbon emissions to low-income countries where regulation is less rigorous.

Existing Australian policy caps the market leakage of carbon for Australian reduced native forest harvest projects at a maximum of 40% (Department of Climate Change Energy the Environment and Water, 2026), which is in the middle of the range of existing international protocols (Haya et al., 2023). Haya et al. (2023) recommended adoption of more conservative (higher) leakage discounts until more robust estimates emerge. Macintosh et al. (2025) went further, concluding that the inherent methodological flaws in improved forest-management carbon credits – including avoided harvesting – are sufficiently severe that such instruments should be phased out of climate policy processes.

The international timber harvest leakage estimate from reduced Australian native forest harvesting, 81.3%, is related but not equivalent to carbon leakage, because of differences in embodied carbon between substitutes (Daigneault et al., 2025). Since 2000-01, 86.8% of that leakage has been to elevated-risk countries, where the risk of poor harvesting practices, and illegal and planned land clearing for purposes including industrial plantation establishment, mean embodied carbon in their native forest and plantation timber products is high (Putz, 2011; Edwards et al., 2014; Brandt et al., 2016; Pearson et al., 2017; Jati et al., 2018; Pendrill et al., 2019a; Pendrill et al., 2019b; Juniyanti et al., 2021; Aryapratama and Pauliuk, 2022). Therefore, 81.3% is proposed as a conservative proxy carbon credit discount for Australian reduced native forest harvest projects until comparative embodied carbon estimates are available.

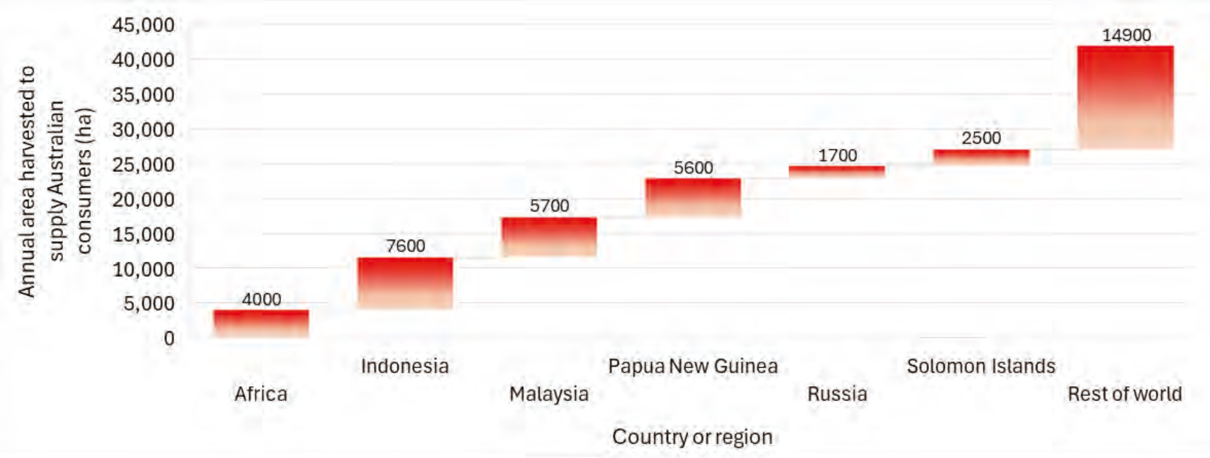
6.3.3 A framework to estimate biodiversity conservation impacts from reduced native forest harvest projects

The substantial direct and indirect impacts of timber harvesting on wildlife in elevated-risk countries are well-known (Barlow et al., 2016; Benitez-Lopez et al., 2017; Jati et al., 2018; Tyukavina et al., 2018; Voigt et al., 2018; Burivalova et al., 2020; Milodowski et al., 2021; Namkhan et al., 2021; Brodie et al., 2023; Consolee et al., 2024; Besisa Nguba et al., 2025; Tondoh et al., 2025), and the biodiversity impacts of large-scale tropical forest clearing for industrial plantation establishment are significant (Barlow et al., 2016; Alroy, 2017; Pendrill et al., 2019a; Pendrill et al., 2019b; Moulatlet et al., 2021; Caro et al., 2022; Cabernard et al., 2024; Cerullo et al., 2024). Estimates of the total area of international forest required to sustainably supply Australia with its imported timber requirements range from 5.7 to 6.2 M ha (Weinzettel et al., 2013; Kan et al., 2023a). Timber harvest leakage from reduced native forest harvest projects can assist quantification of international biodiversity conservation impacts of domestic policy.

Based on the elevated-risk import volumes summarised in Figure 5.10 and published harvest volumes per hectare for international forests (Table A8 in appendices), a preliminary estimate of Australia's annual forest harvest footprint in elevated-risk countries is illustrated in Figure 6.3 at 42,000 ha per annum for the period 2018-19 to 2022-23. There is sufficient information available for some high profile threatened species, such as the orangutan, to evaluate biodiversity conservation impacts.

Native forest logging and broad-scale land clearing for industrial plantation establishment in Malaysia and Indonesia reduces orangutan density by about 50% and 70%, respectively (Voigt et al., 2018). Approximately 72% and 80% of the native forest log harvest from Malaysia and Indonesia, respectively, comes from orangutan habitat areas, and these regions are also the locus of timber plantation expansion (Samejima et al., 2018; Timber Trade Portal, 2026). Given an average population density in less disturbed areas of one adult per 200 ha (Rijksen and Meijaard, 1999) and the harvest areas in Figure 6.3, Australian consumers have been responsible for the loss of about 26 orangutans per annum. Similar analyses could be performed for other species to produce sovereign timber capacity – biodiversity conservation trade-off functions to support policy (Venn 2023).

Figure 6.3. Australia's annual forest harvest area footprint in countries or regions with elevated-risk, 2018-19 to 2022-23



Note: All harvest areas in Africa and specified countries are native forests, except for 500 ha/y of plantation forest in both Indonesia and Malaysia (Table A8). Rest of the world comprised other Southeast Asian nations (68%, principally Vietnam and Thailand), South and Central America (18%) and Eastern Europe (14%).

6.4 Conclusion

Implementation of Australia's reduced native forest harvest policies since the mid-1990s serves as a cautionary tale for the world. These policies have reduced the global supply of solid wood without reducing consumer demand. The long-run impact of reduced native forest harvest policies was to offshore timber production to nations with elevated-risk. Consequently, net global climate and biodiversity conservation benefits of these policies are likely to be negligible or negative. Nations should instead implement forest policies that are informed by science and economics to facilitate sustainable economic development.

6.5 Methods for Estimation of Timber Harvest Leakage

In an open economy, the market for solid wood is competitive, with producers and consumers guided by optimising behaviour to achieve a market equilibrium or materials balance – a state where domestic supply plus net imports equal domestic demand. The market may be frequently impacted by stochastic shocks, including contraction of domestic supply or expansion of housing demand, which observably shifts the market from its long-run equilibrium (e.g. revealing excess demand for wood). However, the competitive market incentivises participants to respond to the disequilibrium and restore the materials balance (e.g. increase imported wood). That is, supply and demand are cointegrated. Despite variables being non-stationary individually, a linear combination of the variables is stationary, which is characteristic of systems with a stable long-term equilibrium (Johansen, 1988). The Vector Error Correction Model (VECM) framework has been adopted for analysis of Australia's timber market because it can simultaneously quantify (i) the short-run dynamics of market shocks, (ii) the long-run cointegrating vector that defines the materials balance, and (iii) the incentivised error-correction behaviour of market participants. By identifying which participants respond to restore the materials balance (endogenous adjusters) and which operate independently as systemic anchors (exogenous drivers or structural forcing variables), the VECM establishes the causal architecture of the timber market (Lutkepohl, 2005). Furthermore, by modelling the long-run timber market equilibrium as a dynamic baseline, the VECM captures the displacement of timber demand – and the resulting market leakage – without the necessity of a counterfactual scenario.

6.5.1 Study period justification and data

When data were collected, the most recent statistics available for some variables in the final VECM were from 2022-23, which determined the study period end date. Data prior to 1996-97 were intentionally excluded to focus analysis on the cointegrating relationships that have governed the Australian timber market since a relatively consistent national policy regime commenced with Australia's first National Forest Policy Statement (Commonwealth of Australia, 1992), which was implemented through ratification of Regional Forest Agreements (RFAs) from 1997. The RFAs and ad-hoc government decisions have progressively transferred large proportions of State Forest to the strict conservation estate before substitute domestic timber resources were available (McAlpine et al., 2005; Timber Queensland, 2024). Strong intent to reduce native forest harvesting was also signalled by the 1997 release of Vision 2020 (Plantation 2020 Vision Implementation Committee, 1997), a joint initiative of the federal and state governments, and the timber industry, that aimed to treble Australia's timber plantation estate to 3 M ha by 2020 (35% achieved by 2024). The federal government renewed its commitment to plantation forestry in 2018 with its Growing a Better Australia plan (Department of Agriculture and Water Resources, 2018) to increase the plantation estate by 400,000 ha within a decade. Australia's plantation area decreased by 226,000 ha (93% hardwood) between 2018-19 and 2023-24 (ABARES, 2025d).

A dataset of annual observations from 1996-97 to 2022-23 (n=27) for 18 variables representing Australia's solid wood supply and demand was compiled (ABARES, 2024a, 2024b; ABS, 2024a, 2024b) and is outlined in the appendices. To protect the model from over-parametrisation, a parsimonious dataset was identified via Lasso (least absolute shrinkage and selection operator) regression in first differences with a one-year lag in Google Colab. This revealed a smaller, theoretically robust set of explanatory variables with greatest influence on materials balance – *NP*, *SP*, *SE* and *DC* – to predict imports (*M*, *AMESS and SSM*). These datasets are defined and summarised in Figure 6.1 and Table A1 (Appendices).

Disaggregated import data were examined within the VECM framework because of expectations of distinct market behaviours due to differences in product types and the bifurcation of Australian forest policy that has supported plantation (softwood) forestry, but not native (hardwood) forestry. The dominant domestic application of *SP* and *SSM* is structural framing for dwellings (ABARES, 2025a). Conversely, market applications of *AMESS* are aligned with applications of Australia's dense, durable and aesthetically pleasing native forest hardwoods (*NP*) (ABARES, 2025e).

To facilitate estimation of Australia's global materials footprint, imported sawnwood and engineered wood product volumes were converted to RWE volume using recovery from log volume factors of 35% and 50%, respectively. Remaining solid wood import categories are recorded in Australia's trade statistics in dollars. Since China supplied 52% of these imports to Australia over the period 2018 to 2022, import dollar values were converted into RWE using Forest Trends (2017) US-dollar to RWE conversion factors for China's exports and applying appropriate inflation and currency adjustments to estimate Australian import volumes. RWE estimation procedures are further explained and justified in Appendix A.1.3. To account for the high annual volatility and non-stationary nature of Australian timber supply and demand, all variables were transformed into natural logarithms for analysis.

6.5.2 Unit root and cointegration tests to confirm suitability of VECM analysis

All data series in the parsimonious dataset were evaluated for unit roots using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests (Dickey and Fuller, 1979; Phillips and Perron, 1988). These tests confirmed that all data series except *SSM* and *SP* were integrated of order one at the 5% significance level, meaning they were non-stationary in levels, but stationary in their first differences (see appendices). *SSM* were stationary in both levels and first differences, indicating they exhibit greater mean reverting behaviour than *AMESS* and act like a consistent commodity flow rather than a reactive domestic supply 'gap filler'. This provided a further justification for disaggregating imports. *SP* stationarity at levels likely reflected sawlog production being better explained by the plantation rotation length rather than short-term market shocks. *SSM* and *SP* were retained in the VECM framework to avoid omitted variable bias. In a multivariate system, the inclusion of stationary variables is valid as they are partitioned into the cointegrating space, ensuring that the estimates for the variables integrated of order one remain consistent and structurally sound (Lutkepohl, 2005). These results satisfied the requirements for Johansen Cointegration analysis (Brooks, 2002).

The existence of one long-run materials balance relationship between the data series (cointegration rank of one; r = 1) was confirmed by standard Johansen Cointegration (Johansen, 1988) and Maximum Eigenvalue (Lutkepohl, 2005) tests conducted with the Reinsel-Ahn (RA) small-sample adjustment (Reinsel and Ahn, 1992). This permitted analysis using the VECM framework. However, given the small sample size, additional tests of the significance of the cointegrating vector were performed. First, following Lutkepohl (2005), a non-parametric bootstrap procedure with 500 iterations was employed to generate an empirical distribution of the maximum eigenvalue statistic, which yielded an empirical p-value that accounted for the variance and covariance structure of the data. Second, to verify dynamic stability, the model was subjected to an eigenvalue stability condition test (Lütkepohl, 2005) to check that the estimated long-run relationship (β), speed of adjustment (α), and short-run dynamics (Γ) represented a convergent transition to a stable market equilibrium. Third, to ensure the long-run materials balance was not biased by structural instability over time, the trace statistic was recalculated as new observations were added to the sample and the Hansen and Johansen (1999) recursive estimation procedure was used to check for structural instability. As highlighted by Goldberger (1991), 'micronumerosity' may inflate estimator variance, but will not bias relationships.

6.5.3 The vector error correction model

Google Colab was used to fit the following VECM to each solid wood import category, $s \in \{M, AMESS, SSM\}$ with the Johansen procedure (Johansen, 1988, 1991, 1995). A constraint of this study was the small sample (n = 27 years) of annual timber production and trade data, which is common in applications of VECM to support natural resource policy (Hassan et al., 2022; Luo and Liang, 2023; McIntosh and Zhang, 2024; Wu et al., 2025). The model was restricted to a first-order lag in differences to mitigate the risk of overfitting and to prioritize the reliability of the long-run cointegrating vector (β) that models the materials balance, over the short-run dynamic complexity (Γ). This is consistent with the small-sample adjustments suggested by Reinsel and Ahn (1992). With annual data, a one-year lag in differences utilizes a two-year 'look-back' period, since Γ is driven by $\Delta y_{t-1} = y_{t-1} - y_{t-2}$.

$$\Delta y_{ts} = \alpha_s(\beta_s' y_{t-1,s}) + \Gamma_s \Delta y_{t-1,s} + \epsilon_{ts} \qquad \text{[eq. 1]}$$

where: t represents the time period;

$y_{t,M} = [\ln(M), \ln(NP), \ln(SP), \ln(SE), \ln(DC)]$;
$y_{t,AMESS} = [\ln(AMESS), \ln(NP), \ln(SP), \ln(SE), \ln(DC)]$;
$y_{t,SSM} = [\ln(SSM), \ln(NP), \ln(SP), \ln(SE), \ln(DC)]$;
$\Delta y_{t-1,s} = y_{t-1,s} - y_{t-2,s}$;
α_s is the loading vector representing the 'loading coefficient' or percentage of the market imbalance from the previous period that is resolved in the current period;
β_s is the long-run cointegrating vector or long-run materials balance coefficient;
Γ_s is the short-run dynamic adjustment matrix; and
ϵ_{ts} is a vector of error terms.

For a 27-year dataset there are 26 'last year' observations. The y_{t-1} in the materials balance part of the equation ($\beta_s' y_{t-1}$) accommodates all the 'last year' observations for all variables in one matrix as follows:

$$\boldsymbol{Y}_{t-1} = \begin{bmatrix} ln(Imports_1) & \cdots & ln(DC_1) \\ \vdots & \vdots & \vdots \\ ln(Imports_{26}) & \cdots & ln(DC_{26}) \end{bmatrix}$$

For a system with a cointegration rank of one, the long-run equilibrium convergence of supply and demand is estimated by fitting the β coefficients to the entire longitudinal data matrix $\boldsymbol{Y}_{t-1}$, as indicated in equation 2.

$$ECT_{t-1} = \beta_{Imports} ln(Imports_{t-1}) + \beta_{NP} ln(NP_{t-1}) + \beta_{SP} ln(SP_{t-1}) + \beta_{SE} ln(SE_{t-1}) + \beta_{DC} ln(DC_{t-1}) \quad \text{[eq. 2]}$$

where ECT_{t-1} is the error correction term representing the lagged deviation from the long-run materials balance; and

$Imports_{t-1}$ are either M_{t-1}, $AMESS_{t-1}$ or SSM_{t-1} depending on the model specification.

Following standard practice for identifying import substitution, equation 2 was normalized on $Imports_{t-1}$ (i.e. $\beta_{Imports}$ = 1) to isolate the structural dependencies of Australian solid wood imports on the remaining variables.

$$ln(Imports_{t-1}) = -\beta_{NP} ln(NP_{t-1}) - \beta_{SP} ln(SP_{t-1}) - \beta_{SE} ln(SE_{t-1}) - \beta_{DC} ln(DC_{t-1}) + ECT_{t-1} \quad \text{[eq. 3]}$$

6.5.4 Tests to confirm unbiased VECM coefficients

Diagnostic tests were performed to ensure estimated long-run substitution effects were unbiased, indicating the model was robust for policy analysis. The absence of serial correlation, and the normality and homoskedasticity of the residuals were tested using the Ljung-Box / Portmanteau (Ljung and Box, 1978; Hosking, 1980), Jarque-Bera (Jarque and Bera, 1987; Lutkepohl, 2005) and Autoregressive Conditional Heteroskedasticity Lagrange Multiplier (ARCH-LM) (Lutkepohl, 2005) tests, respectively, to ensure coefficients were unbiased. Finally, the explanatory power (coefficient of determination, R^2) for individual equations within the VECM, which indicate the proportion of short-run variance explained by the model, was computed following the method described by Enders (2008). Sound explanatory power of the system's equations would confirm that the model specification successfully isolated primary structural drivers of the Australian timber market, ensuring the estimated long-run substitution effects reflect genuine market rebalancing. Full results of diagnostic tests are reported in Appendix A.2.4.

6.5.5 Interpretation of VECM coefficients

Since the VECM framework distinguishes the stochastic short-run dynamics (Γ) from the long-run cointegrating tether (β), the model's utility for providing statistically robust long-term policy projections is decoupled from its ability to predict the short-run impacts of a market shock. Although the VECM demonstrated high explanatory power for the system's short-run dynamics, a conservative interpretation of the Γ coefficients has been adopted due to small sample size. The analysis prioritized the long-run self-correcting mechanism governed by the β and α relationships. This ensures evaluations of the research hypotheses and policy projections are rooted in the stable, multi-decade material balance of the Australian timber market rather than transient stochastic noise. Interpretation and a description of the short-run lagged dynamics (Γ) is provided in the appendices.

All variables were expressed in natural logarithms; thus, β represent long-run elasticities. That is, for the model specified by equations 1 to 3, they represent the long-run percent change in imports for a 1% change in the variable of interest. A negative β coefficient identifies a persistent long-run substitution effect that has remained between import volume and the explanatory variable after the Australian economy had the chance to structurally adjust to find other solutions. Conversely, positive β indicate the variable of interest is complementary to (i.e. moves together with) imports. A negative loading coefficient, α, denotes the percent rate at which a market imbalance (i.e. difference between the short-run equilibrium and β) is closed by that variable annually, thereby (eventually) restoring the long-run materials balance.

The framework established by Engle and Granger (1987) and Granger and Lin (1995) provides the basis for identifying the system's structural causal architecture. Specifically, a variable is identified as an endogenous adjuster if it exhibits a statistically significant α, indicating responsiveness to the equilibrium error. Conversely, a variable is designated as weakly exogenous if it exhibits an insignificant α, indicating non-responsiveness to the equilibrium error. A weakly exogenous variable with a statistically significant β is identified as a long-run structural forcing variable that drives the long-run equilibrium trajectory without itself responding to imbalances (Hall and Milne, 1994). This approach mirrors the structural identification strategy used in Global VAR (GVAR) modelling, where weak exogeneity is leveraged to statistically identify the structural drivers of the endogenous system (Pesaran et al., 2004).

6.5.6 Tests for the research hypotheses and estimation of long-run physical unit multipliers

H1 would be supported if the VECM identified (a) variables that affect domestic net supply (*NP*, *SP*, and *SE*) as long-run structural forcing variables that drive the long-run solid wood market equilibrium trajectory without themselves responding to imbalances, and (b) import volume is an endogenous adjuster variable that reconciles deficits in domestic supply to maintain the materials balance (see Section 6.5.5).

H2 would be supported if β_{NP} and β_{SP} are statistically significant and have opposite signs. The timber with the negative coefficient is an import substitute, the timber with the positive coefficient is an import complement, and by transitive analysis of the cointegrating coefficients, *NP* and *SP* must be complements, not substitutes.

If H1 and H2 are supported, then the persistent structural shift toward import-dependency element of H3 would be confirmed by a statistically significant negative β_{NP}. The second element of H3 required determination of long-run physical unit multipliers, which are also useful to support policy making. The long-run average change in physical units of imports ($\Delta Imports_{\Delta NP}$; *M*, *AMESS* or *SSM* in m^3 RWE) due to a change in the physical level of native forest harvesting (ΔNP in m^3 RWE) has been calculated for the period 1996-97 to 2022-23 with equation 4. To estimate the physical unit change of any variable, *X*, due to a change in any alternative variable *Y*, inputs for equation 4 can be substituted as appropriate.

$$\Delta Imports_{\Delta NP} = \left(\frac{\Delta NP}{\overline{NP}}\right) \times \beta_{NP} \times \overline{Imports} \qquad \text{[eq. 4]}$$

where $\overline{NP}$ is the mean physical value of *NP* (m^3 RWE 1996-97 to 2022-23); and $\overline{Imports}$ is the mean physical value of *M*, *AMESS* or *SSM* (m^3 RWE 1996-97 to 2022-23).

The long-run percent leakage to imports ($\%LM_{NP}$) was then calculated as

$$\%LM_{NP} = \frac{\Delta Imports_{\Delta NP}}{\Delta NP} \qquad \text{[eq. 5]}$$

The second element of H3 would be supported if $\%LM_{NP}$ is greater than 50%, meaning the dominant outcome of reduced native forest harvesting in Australia had been to offshore production. Critically, $\%LM_{NP}$ is derived from the multivariate cointegrating vector (β) that includes other domestic demand and supply variables (i.e. *DC*, *SP*, and *SE*). By internalizing demand-side and other supply-side fluctuations within the long-run equilibrium, the VECM ensured the leakage calculation isolated the structural substitution effect – representing the volume of imports triggered in the long-run by declines in *NP*, after accounting for the simultaneous influence of shifting domestic demand and alternative domestic sources of supply.

To evaluate H4, the reliance of Australia on imports from countries with elevated-risk for the period 1996-97 to 2000-01 ($\%HMR_{96to00}$) and the marginal risk intensity of Australia's imports in the period 2018-19 to 2022-23 ($\%GHMR_{18to22}$) were determined from the ILAT risk analysis.

$$\%HMR_{96to00} = \frac{\overline{HMR}_{96to00}}{\bar{M}_{96to00}} \qquad \text{[eq. 6]}$$

$$\%GHMR_{18to22} = \frac{(\overline{HMR}_{18to22} - \overline{HMR}_{96to00})}{(\bar{M}_{18to22} - \bar{M}_{96to00})} \qquad \text{[eq. 7]}$$

where $\overline{HMR}_{96to00}$ and $\overline{HMR}_{18to22}$ are the mean annual volume of elevated-risk imports for the periods 1996-97 to 2000-01 and 2018-19 to 2022-23 (calculated for *M*, *AMESS* or *SSM*); and

$\overline{M}_{96to00}$ and $\overline{M}_{18to22}$ are the mean annual total import volume for the periods 1996 to 2000 and 2018-19 to 2022-23 (calculated for *M*, *AMESS* or *SSM*).

H4 is supported if the risk intensity ratio (*RIR*) of the increase in imports is greater than 1.

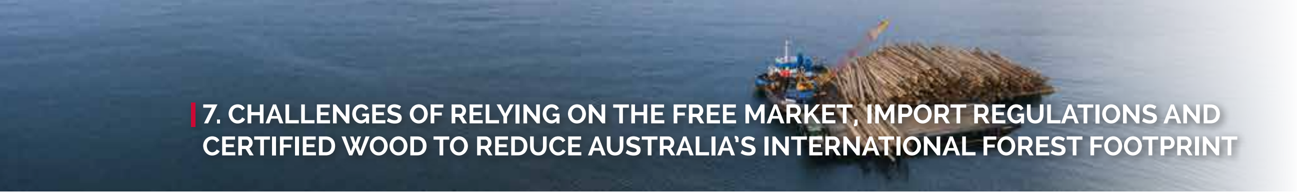
$$RIR = \frac{\%GHMR_{18to22}}{\%HMR_{96to00}} \quad \text{[eq. 8]}$$

To evaluate H5, a policy efficacy threshold of 50% leakage into elevated-risk countries has been adopted. Beyond that point, any potential domestic conservation benefits of reduced harvesting in Australia's highly regulated forests are severely undermined by increases in Australia's environmental impacts in elevated-risk international supply chains. If H3 and H4 are confirmed, then H5 is confirmed if at least 50% of the decrease in native forest log production in Australia had been offset by leakage to elevated-risk countries ($\%RiskLM_{NP}$).

$$\%RiskLM_{NP} = \%GHMR_{18to22} \times \%LM_{NP} \quad \text{[eq. 9]}$$

6.5.7 ILAT Risk Analysis Methods

Please see Section 5.2 for a description of the intersection of Australian and China solid wood product trade data with the Global Illegal Logging and Associated Trade (ILAT) Risk Tool to estimate the volumes of traded wood with elevated-risk.



7. Challenges of Relying on the Free Market, Import Regulations and Certified Wood to Reduce Australia's International Forest Footprint

This chapter highlights that international timber trade represents a textbook example of market failure. Australia's property rights, environmental, social and labour regulations increase costs of domestic production relative to the producers of imported timber products from Africa, Asia and the Pacific, making imported timber attractive substitutes for Australian consumers. Large and unpriced social and environmental costs embodied in imported wood products from developing countries are highlighted in Sections 6.3 and 7.2. Australia's existing policy of free trade in timber products, subject to the Illegal Logging Prohibition Act 2012, is unlikely to slow the growth of the nation's reliance on timber imports from international elevated-risk harvesting hotspots. Furthermore, a potential modified timber trade policy that only allowed certified wood product imports will merely increase aggregate global demand for certified wood without adding to supply. Thus, existing consumers of the finite supply of certified wood will be displaced into uncertified or illegal wood markets.

7.1 Australia's Regulated Timber Industry Struggles to Compete Against Direct and Indirect Imports from Jurisdictions with Fewer Environmental and Labour Constraints

Maintaining the supply of low-cost imported timber is a priority for the Australian federal government at the time of writing (Broom, 2026). As illustrated in Section 5.1, with Australia's economy open to trade, consumers have generally had access to lower cost timber than would have been the case without trade. Australia's relatively high cost of timber production can be largely explained by the cost of regulatory compliance with property rights, environmental and labour laws. Australia's international timber suppliers in Southeast Asia, Papua New Guinea, the Solomon Islands, Russia and the Congo Basin often benefit from low costs of production precisely because they operate in jurisdictions with fewer environmental and labour constraints, and may include corrupt activities (see Sections 6.3 and 7.2).

International timber trade represents a textbook case of market failure, as it systematically fails to internalize the true environmental and social costs of production. Australia can choose to pay higher prices for sustainable domestic timber production or import low-cost, high-risk timber that externalizes the environmental and social costs of production to other countries, including developing nations. If resolution of Australia's domestic timber supply deficit is left to the free market, then Australia's dependence on low-cost, high-risk timber imports will likely continue to increase.

If global environmental and social costs were monetised and added to the cost of imported wood (e.g. through an environmental import tariff), the world price at which Australian consumers could access imported wood, pw in Figure 5.2, would likely be considerably higher. This could incentivise more domestic production and reduce Australia's reliance on imports.

7.2 Timber Import Regulations are Unlikely to Mitigate Australia's International Forest Impacts

In Australia, it is a criminal offence under the Illegal Logging Prohibition Act 2012 (the Act) to import illegally harvested timber (DAFF, 2025). This legislation is similar to the Legal Timber Protection Act (LTPA) in the United States (a 2008 amendment of the 1900 Lacey Act), and the European Union Timber Regulation (EUTR) (Çöpoğlu, 2026). Importers are responsible for determining whether their imports are regulated timber products and perform due diligence to assess and mitigate the risk that the products may include illegally harvested timber. Timber can be imported if the result of due diligence and risk mitigation results in a conclusion that it does not contain illegal timber. Notably, the Act is silent about timber harvested legally according to source country definitions, but implicated with deforestation, native forest clearing for industrial plantation establishment and forest degradation (Harris, 2022; Harris, 2024).

Several studies have raised serious concerns about the integrity of forest certification. For example, in Australia, 63% of sampled imported products with incorrect country-of-origin or incorrect species or genus, had certification (Source Certain, 2025). This finding is consistent with numerous reports about officials being bribed to mix illegal timber with certified timber (van Uhm et al., 2022; Tondoh et al., 2025). Wolff (2022) reviewed 11 studies in tropical countries and Russia that evaluated the deforestation mitigation benefits of certified wood and found 45% of projects had no beneficial effect and the reduction in deforestation for remaining projects was negligible. Rico-Straffon et al. (2025) found certified logging concessions did not reduce deforestation and forest degradation relative to uncertified logging concessions in the Peruvian Amazon. A comparison of greenhouse gas (GHG) emissions from five regions with certified and non-certified forest areas in developing countries, found no difference in GHG emissions in three cases and only a minor decrease in emissions with certification in two cases (Harvey et al., 2025). Therefore, certification does not guarantee a legal or lower environmental impact supply chain.

Illegal logging is responsible for up to 30% of global timber production, including 50% to 90% in many tropical countries (INTERPOL, 2019). The effectiveness of due diligence is limited by poor timber supply chain traceability and transparency that creates opportunities for laundering and leakage (Hoang and Kanemoto, 2021). Illegal logging in Romania (Cozma and Achim, 2023), Ukraine (Turchyn, 2024), Russia (Kirpotin et al., 2021), Solomon Islands (Katovai et al., 2015) and Brazil (Brancalion et al., 2018; Franca et al., 2023) is facilitated by diversified laundering strategies that are used to place illegal timber in compliant supply chains. In Cambodia, highly coordinated structures within a shadow state deeply entwined within formal institutions have facilitated illegal logging in the nation's protected areas, the smuggling of timber across the border into Vietnam's supply chain, and the manipulation of donor agencies such as USAID to fund activities (Work et al., 2023). Trade discrepancy analysis has revealed a high level of under-reporting and imprecise classification in official Vietnamese timber import records, which could be disguising illegal and corrupt activities (Pardo, 2021). In Indonesia, there were 681 reported illegal logging operations over the period 2015 to 2021 (Ministry of Environment and Forestry, 2022). Corrupt political elites manufacture licenses and certifications to facilitate the sale of illegal logs to multi-national crime syndicates who ship Indonesian logs to Malaysia, certify them with Malaysian origin, and then export logs and products to other countries (Baker, 2020; Carry and Maihold, 2022). Taiwanese wood product manufacturers source their feedstock from high-risk nations, including Malaysia, and export their products to the world (Chiou et al., 2021). Singapore acts as an important trade hub for illegal timber, including shipping companies, financiers, and brokers, and ship wood products to the world (Carry and Maihold, 2022).

China, the world's largest exporter of value-added wood products and supplier of 30% of Australia's solid wood imports, relies on imported feedstock for its export-focussed wood manufacturers (Ke et al., 2019; Zhang and Chen, 2021). Since the early 2000s, at least 50% of China's timber imports have been sourced from countries with weak governance, poor rule of law, and documented evidence of widespread illegal harvesting and deforestation (Barbu and Tudor, 2021; Assembe-Mvondo and Kan, 2022; Carry and Maihold, 2022; Richards et al., 2022; Runk, 2022; Kan et al., 2023a; Sheng et al., 2023; Ke et al., 2024; Nijman, 2024; Nijman et al., 2025; Tondoh et al., 2025). China's demand for plantation timber products over the period 2013 to 2023 has been linked to 60,600 ha/y of tropical deforestation for plantation expansion, 56% of which was illegal (Forest Trends, 2025). China's export-oriented wood products industry mixes timber from multiple sources and is not obligated to trace their supply chain (Forest Trends, 2021; Richards et al., 2022; Ke et al., 2024). Some Chinese wood products are re-exported via transit countries and are newly labelled as originating from countries such as Vietnam and Malaysia (Richards et al., 2022). Vasconcelos et al. (2024) performed 20 semi-structured interviews with key informants engaged in EU-China dialogue and concluded that, despite political signals from high-level Chinese leadership, it is unlikely China will adopt trade measures requiring legal and deforestation-free commodities in the foreseeable future.

The reality of international timber supply chains is that illegal timber, as well as timber associated with legal deforestation, native forest clearing for industrial plantation establishment and forest degradation, has been, and may continue to be marketed in Australia while importers fully meet their due diligence requirements under the Illegal Logging Prohibition Act 2012 (Scott, 2024). This finding is consistent with international studies that have concluded timber import regulations are insufficient to keep illegally and unsustainably harvested timber out of supply chains (Norman and Zunino, 2022; Polo Villanueva et al., 2023; Çöpoğlu, 2026).

7.3 Increased Australian Reliance on Imported Certified Wood will Displace Existing Consumers to Uncertified and Elevated-risk Timber

About 11% of the world's forests are certified, with Europe, North America, Australia and New Zealand accounting for 88% of these forests, and low proportions in Asia (6%), Latin America (4%) and Africa (2%) (Bösch, 2025). In recent years, global supply of FSC and PEFC certified industrial roundwood has met approximately 32% of global demand (Bösch, 2025), with illegally sourced hardwood representing about 23% to 30% (World Bank, 2016), and the remainder being mostly legal, but not certified, such as from deforestation and native forest clearing in Indonesia for pulpwood and palm oil plantation expansion (Forest Trends, 2015). Growth in certified timber supply has not kept pace with rising global demand. Indeed, certified timber production declined in recent years due largely to the exclusion of Russia (FSC, 2015; PEFC, 2022; FSC, 2025; PEFC, 2025). The sharp increase in global timber prices associated with forest fires between 2019 and 2021 in Australia, Canada, parts of the EU and the USA, indicated the global supply of certified timber is inelastic (Mensah et al., 2025).

Global industrial roundwood demand is expected to increase by between 55% and 75% over the period 2020 to 2050 (World Bank, 2016; FAO, 2022, 2024b). Inelastic global supply of certified timber means that nations that choose to increase reliance on certified imports will prevent other nations from procuring certified wood. Displaced nations are unlikely to prohibit consumption; rather they will pivot to uncertified or illegal alternatives. FAO (2022, 2024b) projected the world needs to expand timber plantation area by 33 M ha between 2021 and 2050 to satisfy global demand. Which land in which countries should be converted to timber plantations to supply Australia and the world with timber? Finite sustainable global timber supply means that any increase in Australia's demand for imported wood products – even compliant certified imports – adds to aggregate international demand, will drive increases in consumption of uncertified and illegal wood, and will negatively impact global efforts to reduce carbon emissions and conserve biodiversity.

8. Conclusions and Policy Recommendations

Australia's forest policies since the mid-1990s have reduced the global supply of solid wood without reducing consumer demand. The long-run impact of these policies was to exchange sovereign capacity for low-cost timber imports from nations with elevated-risk. Consequently, net global climate and biodiversity conservation benefits of Australia's reduced native forest harvest policies are likely to be negligible or negative. Evidence-based forest, carbon and biodiversity conservation policy reforms are required to encourage actors in Australia's forest and wood product markets to modify behaviour to improve Australia's contribution to global climate and biodiversity conservation targets.

Nations implementing reduced forest harvest policies should adopt carbon credit accounting principles that reflect the true atmospheric impact of domestic policy shifts to minimise the risk that mitigation claims are undermined by unmonitored international displacement, and to maintain the integrity of carbon markets (Gan and McCarl, 2007; Haya et al., 2023). This requires inclusion of international carbon leakage associated with domestic policy changes. This would incentivise policy and practice that reduce emissions to the atmosphere rather than national greenhouse gas account balances. In the Australian context, where harvest leakage since the 1990s has been directed predominantly to elevated-risk timber harvesting hotspots, the timber harvest leakage rate calculated in this study, 81.3%, can serve as a preliminary proxy discount for carbon credits generated by reduced native forest harvest projects. Further research is necessary to quantify inter-country differences in embodied carbon in wood products to estimate carbon leakage from timber harvest leakage. This will likely reveal Australia's carbon leakage from reduced native forest harvest projects is higher than its timber harvest leakage.

Reduced native forest harvest projects justified by biodiversity conservation benefits should account for the impact of domestic forest policy on net global conservation efforts, such as achievement of Kunming-Montreal biodiversity targets (UNEP, 2022). Further research could improve and expand the sovereign timber capacity – biodiversity conservation trade-off framework outlined in Section 6.3.3 and Venn (2023) and develop metrics that enable comparison with domestic impacts.

With the passage of the Illegal Logging Prohibition Act 2012 (the Act), Australia positioned itself as a leader in transboundary environmental governance, formally aligning its trade policies with international frameworks to combat illicit wood trade. The Department of Agriculture, Fisheries and Forestry (DAFF) is the Australian Government agency responsible for enforcing the Act and ensuring compliance of Australian importers of $10 billion per annum in solid wood and paper products (ABARES, 2024a; ABS, 2024a; ABARES, 2025c). DAFF (2022) recognised reliance on desktop auditing of due diligence is vulnerable to document forgery and multi-tier supply chain opacity. This was confirmed by Source Certain (2025), who found that 50% of sampled imported wood products available at Australian retail were not from the country specified, or not of the species or genus specified, or both. The Act was updated in March 2025 to include the use of forensic timber testing technologies and the need for importers to provide DAFF with due diligence information prior to importing or processing the timber (DAFF, 2026). However, at the time of writing, DAFF (2026) indicated 'implementing these reforms effectively will take some time as it requires establishing the necessary IT systems'.

Increased funding for DAFF is critical to overcome current operational bottlenecks and fully operationalise the legislative intent of the Act. The true origin of imported wood can be determined with forensic verification technologies (UNODC, 2016; Grant and Chen, 2021). However, investment is necessary to establish protocols for species-level identification and exact sub-national geographic origin of timber, which requires extensive, specialized reference databases to facilitate forensic testing. Currently, this does not exist for most globally traded priority taxa (Low et al., 2022). Furthermore, a rapid forensic testing system, including the deployment of real-time screening tools at primary maritime entry points, is required (Low et al., 2022). Without baseline chemical and genomic maps, front-line forensic testing cannot easily translate into court-admissible evidence of illicit origin (UNODC, 2016). Research and testing costs could potentially be funded by an industry fee-for-service levy from importers of products from elevated-risk nations, including China, Indonesia, Malaysia, Russia, Thailand and Vietnam.

Consideration of additional trade interventions (e.g. environmental tariffs) to account for legal timber imports that are associated with land clearing or forest degradation (e.g. palm oil and timber plantation expansion in Indonesia and Malaysia), is warranted. This would help to reduce Australian financing of land management practices abroad that are not permitted in Australia. As with fee-for-service forensic testing, tariffs would raise costs in Australia's construction sector. However, higher domestic timber prices could encourage expansion of sovereign capacity and in time reduce Australia's international forest footprint. Ideally, tariff revenues would be invested in projects that support expansion of sovereign timber capacity.

The requirement for mandatory country of origin labelling for all wood products at wholesale and retail should be seriously considered. A survey of 7200 people by consumer group Choice found 99% of respondents wanted to know where and how a timber product was sourced, and most indicated country of origin labelling would sway their buying behaviour (Broom, 2026). Labelling would provide Australian consumers with a clear choice between hardwood timbers from highly regulated forests in places like Australia and North America, versus timbers from Asia, South America, Africa and the Pacific. Mandatory labelling could help reduce Australian demand for timber from elevated-risk nations.

Given the zero-sum game with international certified timber, and contemporary challenges of keeping illegal timber and legal timber that is associated with deforestation, native forest clearing for industrial plantation establishment and forest degradation out of supply chains, developed countries can maximise the contribution of their forests to global efforts to address the climate and extinction crises by implementing policies that secure sovereign timber capacity (Hoang and Kanemoto, 2021). In the Australian context, encouraging expansion of hardwood plantations for solid wood production to add to native forest hardwood supply should be pursued, but will require decades and substantial direct or indirect government investment to overcome high opportunity costs and distant returns (de Fegely et al., 2011; Burns et al., 2015; Downham and Gavran, 2020). Two of the near-term opportunities for Australia to substantially reduce its international forest footprint in elevated-risk harvesting hotspots are to improve management and increase the sustainable timber harvest from domestic public and private native forests (Venn, 2023; Francis et al., 2024), and improve solid wood product recovery from Australia's existing plantation estate (Gutierrez et al., 2023; Millaniyage et al., 2024). Ceasing transfers of State Forests to the conservation estate will have immediate benefits through avoiding the market response to increase timber imports. In the state of Queensland there is considerable potential to increase native forest hardwood production from private land in the short- to medium-term if policy changes are implemented that reduce the sovereign risk that has discouraged investment in native forest management and hardwood processing for decades (Venn, 2023; Francis et al., 2024).

Development of evidence-based carbon credit methods that permit sustainable timber production in native forests could incentivise expansion of native forest cover in agricultural landscapes and increase native forest timber production in the medium to long-term (Venn et al., 2024). In Australia, the only carbon credit methods available for native vegetation management require strict conservation, which is inconsistent with productive agricultural landscapes because of the finite duration of carbon revenues (typically a maximum of 15 to 20 years), the reduction of non-carbon income to effectively zero and legal obligation to protect carbon stocks for the duration of the contract (after carbon income ceases). Unsurprisingly, strict conservation carbon methods have experienced limited adoption in productive agricultural landscapes (Venn et al., 2024).

Finally, improved guidelines for interpreting outputs from national carbon accounts that are compliant with United Nations Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC) methods are urgently required to reduce the risk that these accounts inform the design of perverse forest, carbon and biodiversity conservation policy. For example, the Australian National Carbon Accounting System (NCAS) and the publicly available version of Australia's model to track emissions and removals from the land use, land use change and forestry sector, FullCAM, are not lifecycle analysis models (Australian Government, 2024), although some researchers and policymakers have interpreted outputs as if they are. For example, NCAS and FullCAM do not separately identify and report domestic leakage (although the emissions should be captured by NCAS in the national account) and do not quantify or account for international leakage at all. This means NCAS cannot be used on its own to support an assertion that economic activity in Australia is decoupling from carbon emissions, as made by van Dijk et al. (2025). Nor can NCAS and FullCAM support claims that reduced native forest harvesting in Australia has reduced emissions to the atmosphere by about 35 M t CO_2/y over the period 2016 to 2021, as made by Australian Government (2024).

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Appendices

A.1 Additional information about data used in the VECM analysis, including roundwood equivalent calculations

A.1.1 Datasets considered for VECM analysis

The following 18 variables were considered for the VECM (ABARES, 2024a, 2024b; ABS, 2024a, 2024b):

- Imports: (i) total solid wood imports (*M*), (ii) sawn softwood imports (*SSM*), and (iii) all solid wood imports except sawn softwood (*AMESS*) – sawn hardwood, builders' carpentry (e.g. wood flooring, decking, mouldings, joinery, doors and frames), engineered wood products (EWPs; e.g. plywood, medium density fibreboard and particleboard), and wood furniture (e.g. tables, chairs, bedroom furniture, kitchen and bathroom cabinetry, and storage and display units);
- Domestic supply: (iv) native forest sawlog production (*NP*), (v) softwood plantation sawlog production (*SP*), (vi) hardwood plantation sawlog production, and (vii) EWPs;
- Domestic demand: (viii) dwelling commencements (*DC*), and (ix) national population;
- Exports: (x) softwood plantation log exports (*SE*), (xi) hardwood plantation log exports, (xii) sawn softwood exports, (xiii) sawn hardwood exports, and (xiv) EWP exports; and
- Control variable: (xv) Australian dollar exchange rate; (xvi) dummy variable for COVID-19; (xvii) dummy variable for Global Financial Crisis; and (xviii) dummy variable for Asian Financial Crisis.

A Lasso (least absolute shrinkage and selection operator) regression in first differences with a one-year lag performed in Google Colab revealed the smaller, theoretically robust set of variables defined and summarised in Table A1 and Figure 6.1 that were included in the final model.

Table A1. Summary statistics for VECM variables (1996-97 to 2022-23)

Variable	Mean	Std. Dev.	Min.	Max.
Aggregate imports (*M* = *SSM* + *AMESS*)	4349	1033	2930	6984
Sawn softwood imports (*SSM*)	1770	374	1264	2826
All solid wood imports except sawn softwood (*AMESS*)	2579	856	1118	4158
Native forest sawlog production (*NP*)	2613	924	1076	4008
Softwood plantation sawlog production (*SP*)	8867	1326	5891	10856
Softwood plantation log exports (*SE*)	1568	1154	382	3892
Dwelling commencements (*DC*)	171,363	30,131	122,126	231,298

Note: Dwelling commencements (*DC*) are number of dwellings per annum. All other variables are in 1000 m^3 RWE/y.

Average annual dwelling commencements (*DC*) increased about 40% over the period, which is in line with Australia's population growth. This suggests a strong demand pull for increased consumption of solid wood in structural (e.g. house framing), functional and aesthetic (e.g. decking, mouldings, tables and cabinetry) applications. Average annual Australian softwood plantation sawlog production (*SP*) increased 42% throughout the study period (1996-97 to 2000-01 versus 2018-19 to 2022-23). Sawn softwood imports (*SSM*) fluctuated but remained broadly steady despite rising softwood log exports (*SE*). As annual native forest hardwood sawlog production (*NP*) was on its policy-driven decreasing path, all solid wood imports except sawn softwood (*AMESS*) steadily increased. Australia's total solid wood import volume during the study period was 117 M m^3 RWE.

A.1.2 Description and value of Australian imports of engineered wood products, builders' carpentry, wooden furniture and 'other' miscellaneous wood products

Australia's imports of solid wood products in real (adjusted for inflation) 2022 Australian dollars are illustrated in Figure 5.3 for the period 1996-97 to 2022-23. The real dollar value of solid wood imports tripled during the study period to over AU$6 billion/y.

Sawn softwood and hardwood imports are available in ABARES (2024a) Australian trade data in dollars and cubic metres. Imported wood-based panels or engineered wood products (EWPs) include hardboard, medium density fibreboard, particleboard, plywood, softboard and other fibreboards and veneers. This is the definition of EWPs adopted in this analysis. These imports are reported in ABARES (2024a) by volume and value, which was $992 million in 2022-23.

Presently, ABARES records several types of EWPs in 'Other' within the 'Miscellaneous' wood products category. These include glulam, I-beams, cross-laminated timber (CLT or X-lam) and other engineered structural products, and have been captured within builders' carpentry imports (see below).

Import data for the large 'Miscellaneous' wood product category is available in ABARES (2024a) and includes Builders' carpentry, flooring, mouldings, doors, and 'Other'. The total value of Miscellaneous wood product imports in 2022-23 was $1.73 billion. In 2021-22, Australian imports of 'further processed sawnwood', which broadly aligns with builders' carpentry and related products, accounted for 5.1% of global trade in these products, which ranked Australia third highest by import value after the USA and Germany, and the highest in the world on a per capita basis (UNECE forest products trade flow, https://unece.org/forests/forest-products-trade-flow).

ABARES economists explained that the World Customs Organisation changed the definition of builders' carpentry in 2022, splitting it into further categories of glue-laminated timber (glulam), I-beams, cross-laminated timber (CLT or X-lam), and other EWPs (engineered structural products excluding Glulam, CLT or X-lam and I-beams). ABARES have back dated these changes to 2018. At the time of writing, these products have been shifted into the 'Other' category within 'Miscellaneous' wood products. To remain consistent with previous wood product import reporting by ABARES and previous research by Venn (2023), these product types have been added back to Builders' carpentry in this analysis. Therefore, builders' carpentry analysed in this paper includes ABARES groupings of Builders' carpentry, flooring, mouldings, doors and some types of EWPs (recorded in 'Other'), as specified above.

The 'Other' category includes all other wood products that do not fit into traditional categories. The 2022 import value of this category (excluding the EWPs mentioned above that have been moved to builders' carpentry) was $649 million and included items such as wooden tableware and kitchenware, wooden statuettes and ornaments, wooden frames (e.g. for paintings and photographs), wood marquetry and inlaid wood, wooden caskets, cases, boxes and crates, wooden coffins, coopers' products, wooden tools and tool handles, wooden clothes hangers, and wooden shuttering for concrete construction work.

ABARES ceased reporting secondary wood products, including wood furniture, in their Australian Forest and Wood Products publications and datasets in May 2020 (data available to 2018-19). The wood furniture imports included in this assessment can be found in ABS (2024a) and are limited to the following 10-digit Harmonised Tariff Item Statistical Codes (HTISC) to be consistent with historic ABARES reporting of wood furniture imports and previous analysis by Venn (2023). The total value of wooden furniture imports in 2022-23 was $2.50 billion. In 2021-22, Australian wood furniture imports ranked Australia ninth in the world by value, which accounted for 2.5% of global trade (UNECE forest products trade flow, https://unece.org/forests/forest-products-trade-flow).

- 9401610006 - Seats (excl. swivel seats with height adjustment and seats that convert into beds), with wooden frames, upholstered
- 9401690007 - Seats (excl. swivel seats with height adjustment and seats that convert into beds), with wooden frames (excl. upholstered)
- 9403300041 - Wooden furniture of a kind used in offices
- 9403400024 - Wooden furniture, of a kind used in the kitchen
- 9403500023 - Wooden bedroom furniture
- 9403600025 - Wooden outdoor furniture
- 9403600026 - Wooden coffee tables, nests of tables and similar wooden furniture
- 9403600027 - Wooden buffets, sideboards, wall units and similar wooden furniture
- 9403600028 - Wooden dining tables (excl. kitchen tables)
- 9403600029 - Wooden tables (excl. kitchen, dining and coffee tables or nests of tables and similar wooden furniture)
- 9403600042 - Wooden furniture (excl of a kind used in offices, kitchens, bedrooms & outdoor furniture, coffee/dining/nests of tables, buffets, sideboards, wall units)

These HTISC codes also directed analysis of furniture exports from China to Australia through The General Administration of Customs of the People's Republic of China trade database (available at http://stats.customs.gov.cn/).

A.1.3 Estimating roundwood equivalent (RWE) volumes of wood products

Sawn wood
Only a fraction of log volume can be recovered as sawn or engineered wood products (EWPs). Internationally, reported green-off-saw (GOS) recovery from log volume at sawmills ranges between 35% and 60% for hardwoods and softwoods (FAO et al., 2020). However, this includes all sawn volume, much of which does not meet specifications for structural or appearance applications in regulated markets, such as in Australia, North America and Europe. Several example products are reported in Table A2. These indicate recovery of the types of structural and appearance sawn wood products Australia imports are generally less than 35% of log volume. These products are what makes timber processing profitable –logs are not being grown, harvested and sawn to recover woodchip, wane boards, cants, and pallet timbers. Australian consumer demand for structural and appearance sawn products is driving the harvest of trees. Therefore, adoption of a 35% recovery from log volume is an appropriate and perhaps conservative (given final recoveries in Table A2 are typically less than 35%) estimate of Australia's material footprint associated with consumption of imported sawn wood.

Low final sawn product recovery is a function of wood properties, irregular log shapes, internal log defects, and sawing rectangular shapes from a round log. Also, after the GOS milling stage, there is shrinkage and defects that can arise during drying that need to be docked, losses due to product grading to meet market specifications for appearance or structural applications, and trimming, sanding and planing losses while preparing the product for market (Schlotzhauer et al., 2019).

Engineered wood products (EWPs)
Australia's EWP import volumes are dominated by plywood. Internationally, plywood recovery from log volume has been reported between 37% and 51.2% (FAO et al., 2020). Dry-graded veneer recovery for plywood manufacture from Malaysian *Eucalyptus pellita* plantations is 38% to 50% (Japarudin et al., 2021). Laminated veneer lumber recovery from native forest log volume in Australia is about 42% to 45% (Venn et al., 2021). FAO et al (2020) reported that EWPs made from wood particles (e.g. OSB, fibreboard, MDF, HDF) have recoveries ranging from 42% to 65%. This study has adopted a 50% recovery rate from log volume for all EWPs.

Table A2. Examples of sawn wood recovery from log volume for the types of sawn wood products Australia imports

Nation and source	Sawn or EWP	Final product	Log input	Green-off-saw recovery from log volume	Final recovery from log volume
United States (FAO et al., 2020; Alderman and Brandeis, 2024)	Sawn soft-wood	Structural timber for housing	North American softwoods	49%	30%
New Zealand (Beauregard et al., 2002)	Sawn soft-wood	Structural timber for housing	Radiata pine	61%	27% (F11 and F8 structural timber grades imported by Australia)
Australia (Dunn, 2011; Wong et al., 2024; ABARES, 2025c) and FWPA (2026, https://fwpa.com.au/industry-info/fwpa-public-information/)	Sawn soft-wood	Structural and appearance	Plantation pine	47%	27% (37% if fencing also included)
	Sawn hard-wood	Structural, appearance and infrastructure	Native forest eucalypts	39%	30%
Malaysia (Indufor Oy et al., 2004)	Sawn hard-wood	Usable sawn timber	Tropical forest	48%	33%
Malaysia (Zafhian et al., 2023)	Sawn hard-wood	Sawn wood for furniture	Rubber-wood plantation		26% to 35%
Gabon and **Republic of Congo** (Hawkins and Wigglesworth, 2018)	Sawn hard-wood	Usable sawn timber	Tropical forest		32%
Brazil (Stragliotto et al., 2023)	Sawn hard-wood	Export quality sawn wood	Tropical forest		31% (24% to 40%)
Germany (Stängle et al., 2014; Schlotzhauer et al., 2019; FAO et al., 2020)	Sawn hard-wood	Appearance: Sawn lamellas for the 'wear layer' in engineered flooring.	Ash and maple	51%	33% (including short lamellas). 20% if short lengths excluded
	Sawn hard-wood	Appearance: Sawn wood for furniture, flooring or joinery	Beech	60%	30% (Grade 1 and 2 yield)
Slovakia (Bazjza and Rohanova, 2018)	Sawn hard-wood	Structural timber	Beech	75.3%	16.9%
Spain (Riesco Muñoz et al., 2013)	Sawn hard-wood	Structural-grade beams	Oak	47.6%	8.4% (due to wane and biotic damage)

Builders' carpentry, wooden furniture and 'other'

Builders' carpentry products have lower yield from log volume than the sawn wood or EWPs they are manufactured from, because they are further processed into particular finished dimensions. However, quantifying product volumes is challenging, because trade statistics are reported in dollars. Wood furniture production also results in high volume loss from solid wood inputs. For example, three medium-sized export-focussed teak furniture manufacturers in Indonesia were found to recover an average of 26.2% of sawn timber in the final product (Prasetyo et al., 2018). Recovery from tropical sawn wood used in Nigerian furniture manufacture was found to be about 50% (Larinde and Erakhrumen, 2021). Thus, if GOS volume purchased from a sawmill accounted for 60% of log volume, then final furniture recovery from log volume indicated by these studies was 15.7% to 30%.

Builders' carpentry, wooden furniture and 'other' wood imports are recorded in Australia's trade data in dollars, not wood product volume. Developing countries and China accounted for 70%, 92% and 64% of the value of each of these import categories, respectively (2018-19 to 2022-23). By value, China alone accounted for 26% of Australia's builders' carpentry imports, 62% of wooden furniture imports and 46% of 'other' wood imports. Following Venn (2023), United States dollar import value to volume ratios for China's exports to Australia reported by Forest Trends (2017) were currency and inflation-adjusted to estimate imported RWE volumes in 2022 Australia dollars.

Table A3 summarises the estimation procedure. The second column reports the 2016 estimates from Forest Trends (2017). For example, the wood furniture ratio was 496 m^3 RWE per million Australian dollars spent on wood furniture imports. The third and fourth columns of Table A3 provide the inflation adjusted m^3 RWE/ AU$ million and the implied price per m^3 RWE in 2022-23, as used in the VECM analysis. The fifth and sixth columns of Table S4 provide inflation adjustment to 2026, which facilitates comparison with import prices at the time of writing. If these 2026 values per m^3 RWE (inflated from 2016) provide a good estimate of actual imported wood prices in 2026, then the forest trends conversion provides a sound estimate of miscellaneous wood product volumes, including builders' carpentry and wooden furniture, that Australian trade statistics record in dollars.

Table A3. Inflation adjustment of Forest Trends (2017) RWE wood import values for Australia to 2022 and 2026

Product	2016 m^3 RWE/ AU$ million in 2016	Inflation adjusted m^3 RWE/ AU$ million in 2022	2022 AU$/$m^3$ RWE	Inflation adjusted m^3 RWE/ AU$ million in 2026	2026 AU$/$m^3$ RWE
Builders' carpentry	670	600	1667	524	1909
Wood furniture	496	444	2252	388	2580
'Other' miscellaneous	440	394	2538	344	2907

Table A4 provides examples of imported builders' carpentry and wooden furniture prices in Australia in April 2026. The first four products are builders' carpentry, with prices ranging from $864 to $3520/$m^3$ RWE, and a mean of $1800/$m^3$, providing a

good fit with Table A3. The final three products in Table A4 are imported solid wood timber furniture items. They ranged in value from \$1291 to \$3913/m^3 RWE, with an average of 2610/m^3 RWE. This also provides a good fit with Table A3. Thus, the Forest Trends (2017) factors to calculate RWE import volumes from dollar values continues to provide a sound fit in 2026, and therefore provides an appropriate method to estimate these product volumes in the study period.

Table A4. Examples of imported builders' carpentry and wooden furniture prices in 2026

Imported product	Australian 2026 wholesale price (\$/m^3 product)	Subtract 25% wholesale mark-up (\$/m^3 product) [f]	Australian 2026 import price in \$/m^3 RWE [g]
China imported timber stairs [a,c,h]	5000 to 11,000	4000 to 8800	1200 to 2640
China imported joinery [a,c,h]	3600 to 14667	2880 to 11734	864 to 3520
Merbau decking [a,d,i]	4800	3840	1152
Meranti moulding [a,d,i]	9228	7382	2215
Engineered wood flooring [a,d,i]	4750 to 6000	3800 to 4800	1634 to 2064
Shorea hardwood outdoor dining table and four chairs [b,e,j]	10924	8739	2622
Rubberwood coffee table [b,e,j]	5380	4304	1291
Rubberwood table and 2 stool set [b,e,j]	16,306	13045	3913

Notes: a. Builders' carpentry product.
b. Solid wood furniture product.
c. Assumes 0.5 m^3 of sawnwood for a single flight of straight stairs and 0.15 to 0.25 m^3 per linear metre for China joinery.
d. Price per m^3 calculated from product dimensions and for the engineered flooring assume 50 m^2 per m^3 of EWP.
e. The wholesale price and total weight of each set of furniture was converted into a price per m^3 assuming an air-dry density of 600 kg/m^3.
f. The import price for consistency with Australian trade statistics was approximated by subtracting a 25% wholesale mark-up.
g. For comparison with currency and inflation-adjusted Forest Trends (2017) (last column in Table S4). imported \$/m^3 RWE data, this column converts the import price per m^3 product in column three to an import price per m^3 RWE. This assumes a 30% recovery from log volume for all products (sized from sawn wood), except the engineered flooring where 43% was used to account for higher EWP recovery (Venn et al., 2021).

Source: h. https://www.supplynet.com.au/post/building-materials-cost-guide-for-builders-2026#:~:text=How%20much%20do%20building%20materials%20cost%20in,from%20$45%20to%20$280%20per%20square%20metre.
i. https://www.canterburytimbers.com.au/.
j. https://www.theimportdepot.com.au/.

A.2 Detailed VECM results and diagnostic tests

A.2.1 Unit Root tests that justified adopting the VECM framework

The table below indicates that the Augmented Dickey-Fuller (ADF) results for most variables confirmed non-stationarity in levels and stationarity in first differences, as required for VECM analysis. However, the high annual volatility in trade data led to inconclusive ADF results for Imports and SP series. Consequently, the Phillips-Perron (PP) test was utilized as a robust alternative, that better accounts for the heteroskedasticity and potential structural breaks likely to be inherent in Australian timber supply-chain data. The PP test confirmed that all variables are integrated of order one at the 5% significance level, satisfying the requirements for Johansen cointegration analysis.

The stationarity of the log-transformed series was assessed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The PP test provided a robust alternative to the ADF that better accounts for the heteroskedasticity and potential structural breaks likely to be inherent in Australian timber supply-chain data. The table below summarizes the unit root test results. The goal with the ADF and PP tests is for the data to be non-stationary in levels (Lvl *p* >0.05), but stationary in differences (Diff *p* < 0.05). In their levels, all variables except SSM and SP were non-stationary. The PP test yielded significant stationary in differences results across the entire dataset. This confirms that the variables share a stochastic trend and justifies the use of a VECM to investigate the long-run equilibrium relationships between domestic production, net imports and domestic demand.

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AUGMENTED DICKEY-FULLER (ADF) AND PHILLIPS-PERRON (PP) TEST RESULTS
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Variable	ADF_Lvl_p	ADF_Diff_p	PP_Lvl_p	PP_Diff_p
M (total) Imports	0.9954	0.6008	0.6520	0.0000
AMESS imports	0.3907	0.1688	0.2472	0.0000
SSM imports	0.0010	0.0000	0.0010	0.0000
NP	0.9946	0.0004	0.9989	0.0012
SP	0.0064	0.6190	0.0179	0.0002
SE	0.1211	0.0323	0.5156	0.0302
DC	0.9275	0.0266	0.4037	0.0180

Note: goal is Lvl *p* > 0.05 (non-stationary) and Diff *p* < 0.05 (stationary)

As indicated in the body of the paper, with *SSM* stationary in both levels and first differences, this likely indicates greater mean reverting behaviour than *AMESS* and act like a consistent commodity flow rather than a reactive domestic supply 'gap filler'. This provided a further justification for disaggregating imports. *SP* stationarity at levels likely reflected sawlog production being better explained by the plantation rotation length rather than short-term market shocks. *SSM* and *SP* were retained in the VECM framework to avoid omitted variable bias. In a multivariate system, the inclusion of stationary variables is valid as they are partitioned into the cointegrating space, ensuring that the estimates for the variables integrated of order one remain consistent and structurally sound (Lutkepohl, 2005). These results satisfied the requirements for Johansen Cointegration analysis (Brooks, 2002).

A.2.2 Summary of the main AMESS and SSM VECM results, including model diagnostic tests

To maintain analytical focus, Table A5 reports (a) short-run (Γ) coefficients for the import response equation, (b) the loading (α) and long-run coefficients (β), (c) long-run physical unit multipliers, and (d) model diagnostics for the disaggregated market VECM specifications – *AMESS* and *SSM*. Guidelines for interpreting model coefficients are provided in the methods. The complete system of short-run equations for all model specifications have been provided in Appendix A.2.3, and full presentation and descriptions of model diagnostics for the *AMESS* and *SSM* specifications are provided in Appendix A.2.4.

In brief, the *AMESS* specification passed all model diagnostic tests, confirming cointegration rank of one with unbiased and economically robust coefficients that provide a sound basis for estimating the long-run impacts of forest policy and timber supply-chain dependencies. The *SSM* specification passed six of the eight diagnostic tests, revealing a weaker cointegration of rank one and unbiased coefficients. The signs of significant *SSM* coefficients can be interpreted with confidence; however, magnitudes should be interpreted cautiously.

Table A5 reports the long-run physical unit multipliers for imports that adjust to restore equilibrium in the Australian timber market ($\Delta AMESS_{\Delta Y}$ and $\Delta SSM_{\Delta Y}$ in m^3 RWE). These were calculated with equation 4 (methods) and assume a one-time 100,000 m^3 RWE reduction in each weakly exogenous variable with a statistically significant β. Given confirmation of Hypotheses 1 and 2, $\Delta AMESS_{\Delta NP}$ indicates that a 100,000 m^3 RWE decrease in *NP* forces a long-run structural increase in *AMESS* of 81,300 m^3 RWE, representing an international leakage rate of 81.3%.

Table A5. VECM coefficients, model diagnostics and physical unit multipliers (for a one-time 100,000 m^3 RWE reduction) for the *AMESS* and *SSM* specifications

Variable and model diagnostic	Market with all solid wood imports except sawn softwood (*AMESS*)				Market with sawn softwood imports (*SSM*)			
	Coefficients and model diagnostics [a]			Significant long-run physical unit multiplier, $\Delta AMESS_{\Delta Y}$(m^3 RWE)	Coefficients and model diagnostics [a]			Significant long-run physical unit multiplier, $\Delta SSM_{\Delta Y}$(m^3 RWE)
	Loading (α)	Long-run (β) [b]	Short-run (Γ)		Loading (α)	Long-run (β) [b]	Short-run (Γ)	
Constant			4.46**				20.43***	
ln(*AMESS*)	-0.1591**	1.0000***	-0.0871					
ln(*SSM*)					-0.4642***	1.0000***	-0.1336	
ln(*NP*)	-0.0968	-0.8243***	0.6877**	81,314	-0.0188	-0.3481	1.0086	
ln(*SP*)	0.0832	1.8497***	0.6869**	-53,822	0.0668	-0.1458	1.0734	
ln(*SE*)	0.2765	0.3795***	-0.1241*	-62,492	0.2418	0.6028***	-0.3686*	-68,105
ln(*DC*)	-0.2999***	-2.7346***	0.2206		-0.2009***	-3.0566***	1.1386	
RA-adjusted Johansen Cointegration test stat. [c]	r ≤ 0: 70.37 and r ≤ 1: 28.88				r ≤ 0: 55.50 and r ≤ 1: 25.19			
RA-adjusted Max Eigenvalue test stat. [d]	r ≤ 0: 47.74 and r ≤ 1: 13.21				r ≤ 0: 38.81 and r ≤ 1: 16.50			
Eigenvalue Dynamic Stability test [e]	0.728				0.638			
Recursive Trace Ratio test [f]	1.32				1.10			
Bootstrapped Maximum Eigenvalue test [g]	60.61 (p = 0.026)				48.15 (p = 0.166)			
Log-likelihood	169.01				132.64			
AIC	-268.03				-195.28			
BIC	-225.37				-152.62			
R^2 [h]	*AMESS* 0.57, *NP* 0.32, *SP* 0.24, *SE* 0.20, *DC* 0.88				*SSM* 0.45, *NP* 0.29, *SP* 0.22, *SE* 0.21, *DC* 0.80			
Ljung-Box / Portmanteau [i]	193.5 (0.9009)				184.3 (0.9618)			
Jarque-Bera [i]	4.37 (0.9293)				17.29 (0.0682)			
ARCH-LM [i]	242.72 (0.1988)				235.43 (0.3031)			

Notes: a. Levels of significance for model coefficients are p <0.05 *, p <0.01 **, p <0.001 ***.

b. Following standard VECM reporting protocols (Johansen and Juselius, 1990), the β coefficients have been sign corrected to reflect their directional impact on imports.

c. The Reinsel-Ahn (RA) corrected 95% critical values for the Johansen Cointegration Test Trace Statistic are 69.82 for $r \leq 0$ and 47.85 for $r \leq 1$. *AMESS* has one cointegrating vector (r = 1).

d. The Reinsel-Ahn (RA) corrected 95% critical values for the Maximum Eigenvalue Test are 33.88 for $r \leq 0$ and 27.58 for $r \leq 1$. *AMESS* and *SSM* have one cointegrating vector (r = 1).

e. Maximum moduli of the stationary roots are less than the critical value of 1.0, indicating both VECM specifications possesses a stable cointegration.

f. Minimum recursive trace ratios from Hansen and Johansen (1999) exceed the critical value of 1.0, indicating both VECM specifications have a stable cointegrating relationship over time.

g. Cointegration is confirmed if p < 0.05.

h. R^2 measures the explanatory power of the model in predicting short-run changes in each variable. This is a much stricter test than a levels-based R^2. The lower R^2 for *NP*, *SP* and *SE* are expected since they are weakly exogenous variables.

i. Each multivariate (system-wide) test statistic is reported followed by p-value in parentheses. The critical value for all tests is p > 0.05.

A.2.3 Complete VECM results for the M, AMESS and SSM specifications

The following pages report the complete VECM results for the aggregate imports specification (*M*), as well as the disaggregated specifications – *AMESS* and *SSM*. This section begins with a description of aggregation bias in the VECM for *M*.

Description of problems with results from the aggregate imports (*M*) specification

Australia's timber market is fundamentally disaggregated into *AMESS* and *SSM*, each with distinct structural drivers. The coefficients in this aggregate model, *M*, represent, at best, a market average. At worst, they represent the effect of severe aggregation bias, which makes interpretation of coefficients invalid.

The loading coefficient for aggregate imports (α_M = -0.819, $p < 0.001$) suggests approximately 82% of any disequilibrium in the timber supply-demand balance is corrected within a single year by aggregate imports. However, the disaggregated models for *SSM* (α_{SSM} = -0.46, $p = 0.001$) and *AMESS* (α_{AMESS} = -0.16, $p = 0.01$) reveal substantially slower adjustment velocities. Given that the long-run (β) coefficients identified these sectors as complements rather than substitutes, the high α_M cannot be explained by inter-sectoral rebalancing. There is a similar inconsistency with the very high α_{DC} in the aggregate imports model specification (= -0.7135, $p < 0.001$) relative to the disaggregated markets (-0.2 to -0.3, $p < 0.001$). There are also difficult to reconcile beta coefficients in the aggregate model. For example, β_{DC} (0.5059, $p < 0.001$), is one-sixth of its level in both disaggregated models. The much higher β_{DC} in the disaggregated models can be reconciled with the reality that one Australian dwelling uses an average of about 45 m^3 RWE of solid wood. That is, a 1% change in *DC* will likely be associated with a greater than 1% change in imports, *ceteris paribus*.

These and other discrepancies reflect severe aggregation bias, where the summation of different timber markets smoothed idiosyncratic 'noise' and logistical frictions inherent in specific supply chains. By neutralizing the higher variance found in specific markets, the aggregate model overestimated the system's ability to resolve supply-chain imbalances. This further highlighted the necessity of disaggregated modelling.

The analysis of disaggregated timber import data suggests Australia's solid wood timber market can be broadly categorised into: (a) one balanced by *AMESS* – imports of sawn hardwood, builders' carpentry (e.g. flooring, decking, mouldings, joinery, doors and frames), EWPs and wooden furniture; and (b) one balanced by *SSM* – imports of sawn softwood for structural house framing.

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THE AGGREGATE (*M*) VECM

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--- VECM Estimation Results ---

Det. terms outside the coint. relation & lagged endog. parameters for equation Imports

	coef	std err	z	P>|z|	[0.025	0.975]
const	11.2096	3.178	3.527	0.000	4.980	17.439
L1.Imports	-0.0256	0.263	-0.097	0.923	-0.542	0.491
L1.Native_Prod	0.7808	0.376	2.078	0.038	0.044	1.517
L1.Softwood_Prod	0.4877	0.443	1.100	0.271	-0.381	1.357
L1.Softwood_Export	-0.1964	0.090	-2.180	0.029	-0.373	-0.020
L1.Commencements	0.4492	0.397	1.131	0.258	-0.329	1.228

Det. terms outside the coint. relation & lagged endog. parameters for equation Native_Prod

	coef	std err	z	P>|z|	[0.025	0.975]
const	2.8099	2.165	1.298	0.194	-1.434	7.054
L1.Imports	0.1035	0.180	0.577	0.564	-0.248	0.455
L1.Native_Prod	-0.2697	0.256	-1.053	0.292	-0.771	0.232
L1.Softwood_Prod	0.3609	0.302	1.195	0.232	-0.231	0.953
L1.Softwood_Export	0.0156	0.061	0.254	0.799	-0.105	0.136
L1.Commencements	0.1961	0.271	0.725	0.469	-0.334	0.727

Det. terms outside the coint. relation & lagged endog. parameters for equation Softwood_Prod

	coef	std err	z	P>|z|	[0.025	0.975]
const	-2.6851	2.047	-1.312	0.190	-6.697	1.327
L1.Imports	-0.0366	0.170	-0.216	0.829	-0.369	0.296
L1.Native_Prod	-0.2975	0.242	-1.229	0.219	-0.772	0.177
L1.Softwood_Prod	0.3260	0.286	1.142	0.253	-0.234	0.886
L1.Softwood_Export	-0.0314	0.058	-0.541	0.589	-0.145	0.082
L1.Commencements	0.2938	0.256	1.149	0.251	-0.208	0.795

Det. terms outside the coint. relation & lagged endog. parameters for equation Softwood_Export

	coef	std err	z	P>|z|	[0.025	0.975]
const	-7.7385	11.963	-0.647	0.518	-31.185	15.708
L1.Imports	-0.6887	0.992	-0.694	0.487	-2.633	1.255
L1.Native_Prod	-2.1004	1.414	-1.485	0.137	-4.872	0.671
L1.Softwood_Prod	1.6622	1.669	0.996	0.319	-1.608	4.933
L1.Softwood_Export	0.1449	0.339	0.427	0.669	-0.520	0.810
L1.Commencements	1.6905	1.495	1.131	0.258	-1.239	4.620

Det. terms outside the coint. relation & lagged endog. parameters for equation Commencements

	coef	std err	z	P>|z|	[0.025	0.975]
const	9.7338	0.780	12.487	0.000	8.206	11.262
L1.Imports	0.4123	0.065	6.380	0.000	0.286	0.539
L1.Native_Prod	0.3748	0.092	4.068	0.000	0.194	0.555
L1.Softwood_Prod	0.4947	0.109	4.550	0.000	0.282	0.708
L1.Softwood_Export	-0.1588	0.022	-7.186	0.000	-0.202	-0.115
L1.Commencements	0.2347	0.097	2.410	0.016	0.044	0.426

Loading coefficients (alpha) for equation Imports

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	-0.8188	0.233	-3.510	0.000	-1.276	-0.362

Loading coefficients (alpha) for equation Native_Prod

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	-0.2118	0.159	-1.333	0.183	-0.523	0.100

Loading coefficients (alpha) for equation Softwood_Prod

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	0.1962	0.150	1.306	0.192	-0.098	0.491

Loading coefficients (alpha) for equation Softwood_Export

	coef	std err	z	P>|z|	[0.025	0.975]

```
ec1            0.5569       0.878       0.634       0.526      -1.164       2.278
           Loading coefficients (alpha) for equation Commencements
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.7135      0.057    -12.469      0.000      -0.826      -0.601
          Cointegration relations for loading-coefficients-column 1
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
beta.1         1.0000          0          0      0.000       1.000       1.000
beta.2         0.3327      0.045      7.459      0.000       0.245       0.420
beta.3        -0.2272      0.077     -2.938      0.003      -0.379      -0.076
beta.4        -0.1872      0.036     -5.150      0.000      -0.258      -0.116
beta.5         0.5059      0.121      4.176      0.000       0.268       0.743
==============================================================================
```

Complete VECM results for the *AMESS* specification

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THE *AMESS* VECM

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--- VECM Estimation Results ---
Det. terms outside the coint. relation & lagged endog. parameters for equation Imports
=====================================================================================
                        coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------------
const                 4.4614      1.704      2.619      0.009       1.122       7.801
L1.Imports           -0.0871      0.216     -0.404      0.686      -0.510       0.335
L1.Native_Prod        0.6877      0.238      2.886      0.004       0.221       1.155
L1.Softwood_Prod      0.6869      0.252      2.725      0.006       0.193       1.181
L1.Softwood_Export   -0.1241      0.057     -2.181      0.029      -0.236      -0.013
L1.Commencements      0.2206      0.245      0.898      0.369      -0.261       0.702
Det. terms outside the coint. relation & lagged endog. parameters for equation Native_Prod
=====================================================================================
                        coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------------
const                 2.5894      1.836      1.411      0.158      -1.008       6.187
L1.Imports            0.2526      0.232      1.088      0.277      -0.203       0.708
L1.Native_Prod       -0.2354      0.257     -0.917      0.359      -0.739       0.268
L1.Softwood_Prod      0.4653      0.272      1.713      0.087      -0.067       0.998
L1.Softwood_Export   -0.0032      0.061     -0.052      0.958      -0.123       0.117
L1.Commencements      0.1341      0.264      0.507      0.612      -0.384       0.653
Det. terms outside the coint. relation & lagged endog. parameters for equation Softwood_Prod
=====================================================================================
                        coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------------
const                -2.3127      1.722     -1.343      0.179      -5.687       1.062
L1.Imports            0.0714      0.218      0.328      0.743      -0.356       0.498
L1.Native_Prod       -0.3275      0.241     -1.360      0.174      -0.799       0.145
L1.Softwood_Prod      0.3291      0.255      1.292      0.197      -0.170       0.828
L1.Softwood_Export   -0.0323      0.058     -0.561      0.575      -0.145       0.080
L1.Commencements      0.1889      0.248      0.761      0.446      -0.297       0.675
Det. terms outside the coint. relation & lagged endog. parameters for equation Softwood_Export
=====================================================================================
                        coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------------
const                -7.7626     10.179     -0.763      0.446     -27.713      12.188
L1.Imports           -0.8556      1.288     -0.664      0.506      -3.380       1.669
L1.Native_Prod       -2.1517      1.424     -1.511      0.131      -4.942       0.639
L1.Softwood_Prod      1.8042      1.506      1.198      0.231      -1.148       4.757
L1.Softwood_Export    0.1633      0.340      0.480      0.631      -0.503       0.830
L1.Commencements      1.4750      1.467      1.006      0.315      -1.400       4.350
Det. terms outside the coint. relation & lagged endog. parameters for equation Commencements
=====================================================================================
                        coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------------
const                 8.2821      0.725     11.430      0.000       6.862       9.702
L1.Imports            0.4474      0.092      4.880      0.000       0.268       0.627
L1.Native_Prod        0.4476      0.101      4.417      0.000       0.249       0.646
L1.Softwood_Prod      0.5423      0.107      5.057      0.000       0.332       0.752
L1.Softwood_Export   -0.1732      0.024     -7.156      0.000      -0.221      -0.126
L1.Commencements      0.3822      0.104      3.661      0.000       0.178       0.587
              Loading coefficients (alpha) for equation Imports
==============================================================================
```

```
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.1591      0.062     -2.574      0.010      -0.280      -0.038
            Loading coefficients (alpha) for equation Native_Prod
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.0968      0.067     -1.454      0.146      -0.227       0.034
           Loading coefficients (alpha) for equation Softwood_Prod
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1            0.0832      0.062      1.332      0.183      -0.039       0.206
          Loading coefficients (alpha) for equation Softwood_Export
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1            0.2765      0.369      0.749      0.454      -0.447       1.000
           Loading coefficients (alpha) for equation Commencements
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.2999      0.026    -11.407      0.000      -0.351      -0.248
          Cointegration relations for loading-coefficients-column 1
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
beta.1         1.0000          0          0      0.000       1.000       1.000
beta.2         0.8243      0.105      7.873      0.000       0.619       1.030
beta.3        -1.8497      0.188     -9.823      0.000      -2.219      -1.481
beta.4        -0.3795      0.085     -4.454      0.000      -0.546      -0.212
beta.5         2.7346      0.290      9.413      0.000       2.165       3.304
==============================================================================
```

Complete VECM results for the *SSM* specification

=============

THE *SSM* VECM

=============

```
--- VECM Estimation Results ---
Det. terms outside the coint. relation & lagged endog. parameters for equation Imports
======================================================================================
                         coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------
const                 20.4284      6.242      3.273      0.001       8.194      32.663
L1.Imports            -0.1336      0.248     -0.540      0.589      -0.619       0.352
L1.Native_Prod         1.0086      0.747      1.349      0.177      -0.456       2.474
L1.Softwood_Prod       1.0734      0.896      1.198      0.231      -0.683       2.830
L1.Softwood_Export    -0.3686      0.168     -2.193      0.028      -0.698      -0.039
L1.Commencements       1.1386      0.754      1.511      0.131      -0.338       2.616
Det. terms outside the coint. relation & lagged endog. parameters for equation Native_Prod
======================================================================================
                         coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------
const                  0.7492      2.156      0.348      0.728      -3.476       4.975
L1.Imports            -0.0514      0.085     -0.602      0.547      -0.219       0.116
L1.Native_Prod        -0.3288      0.258     -1.274      0.203      -0.835       0.177
L1.Softwood_Prod       0.2441      0.309      0.789      0.430      -0.363       0.851
L1.Softwood_Export     0.0515      0.058      0.886      0.375      -0.062       0.165
L1.Commencements       0.3183      0.260      1.223      0.221      -0.192       0.828
Det. terms outside the coint. relation & lagged endog. parameters for equation Softwood_Prod
======================================================================================
                         coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------
const                 -2.9472      1.991     -1.480      0.139      -6.850       0.956
L1.Imports            -0.0052      0.079     -0.066      0.948      -0.160       0.150
L1.Native_Prod        -0.3032      0.238     -1.272      0.204      -0.771       0.164
L1.Softwood_Prod       0.2372      0.286      0.830      0.407      -0.323       0.797
L1.Softwood_Export    -0.0280      0.054     -0.522      0.602      -0.133       0.077
L1.Commencements       0.2415      0.240      1.005      0.315      -0.230       0.713
Det. terms outside the coint. relation & lagged endog. parameters for equation Softwood_Export
======================================================================================
                         coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------
const                -10.7838     11.610     -0.929      0.353     -33.538      11.970
```

```
L1.Imports             -0.2231      0.460     -0.485      0.628     -1.125      0.679
L1.Native_Prod         -2.0998      1.390     -1.511      0.131     -4.824      0.625
L1.Softwood_Prod        1.6890      1.667      1.013      0.311     -1.577      4.955
L1.Softwood_Export      0.1329      0.313      0.425      0.671     -0.480      0.746
L1.Commencements        1.1101      1.402      0.792      0.428     -1.637      3.857
Det. terms outside the coint. relation & lagged endog. parameters for equation Commencements
=========================================================================================
                         coef    std err          z      P>|z|      [0.025      0.975]
-----------------------------------------------------------------------------------------
const                   8.8433      1.046      8.453      0.000      6.793     10.894
L1.Imports              0.1017      0.041      2.450      0.014      0.020      0.183
L1.Native_Prod          0.3248      0.125      2.593      0.010      0.079      0.570
L1.Softwood_Prod        0.6335      0.150      4.218      0.000      0.339      0.928
L1.Softwood_Export     -0.1300      0.028     -4.614      0.000     -0.185     -0.075
L1.Commencements        0.5182      0.126      4.103      0.000      0.271      0.766
              Loading coefficients (alpha) for equation Imports
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.4642      0.142     -3.268      0.001     -0.743     -0.186
            Loading coefficients (alpha) for equation Native_Prod
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.0188      0.049     -0.383      0.702     -0.115      0.077
           Loading coefficients (alpha) for equation Softwood_Prod
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1            0.0668      0.045      1.475      0.140     -0.022      0.156
          Loading coefficients (alpha) for equation Softwood_Export
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1            0.2418      0.264      0.916      0.360     -0.276      0.759
           Loading coefficients (alpha) for equation Commencements
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.2009      0.024     -8.442      0.000     -0.248     -0.154
          Cointegration relations for loading-coefficients-column 1
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
beta.1         1.0000          0          0      0.000      1.000      1.000
beta.2         0.3481      0.191      1.818      0.069     -0.027      0.723
beta.3         0.1458      0.332      0.439      0.661     -0.506      0.797
beta.4        -0.6028      0.157     -3.840      0.000     -0.910     -0.295
beta.5         3.0566      0.518      5.905      0.000      2.042      4.071
==============================================================================
```

A.2.4 Detailed diagnostic test results for the AMESS and SSM VECM specifications

Summary

The *AMESS* specification passed all model diagnostic tests ($p < 0.05$). A cointegration rank of one was confirmed, proving the existence of a persistent long-run materials balance between domestic production, net imports and domestic demand. Tests for serial correlation, and normality and homoskedasticity of the residuals confirmed magnitudes of coefficients are unbiased and economically robust, such that the *AMESS* specification provides a sound basis for estimating the long-run impacts of forest policy and timber supply-chain dependencies.

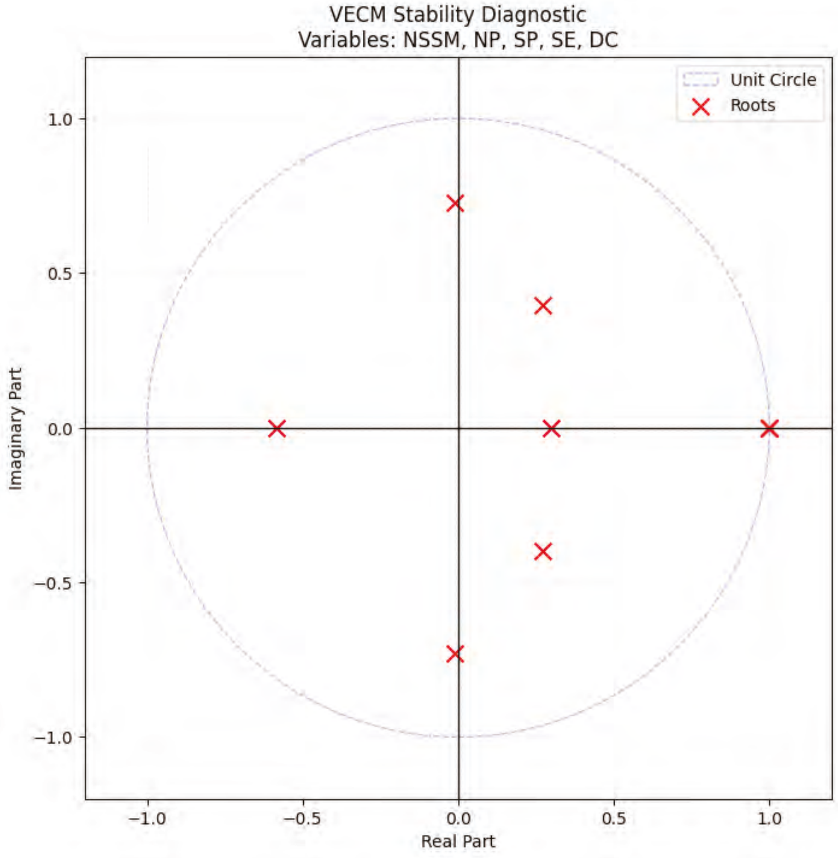
The *SSM* specification passed three of the five tests confirming a significant first order cointegration, failing the RA-adjusted Johansen test ($r \leq 0$: 55.50, crit 69.82) and the bootstrapped maximum eigenvalue test ($p = 0.16$). This suggests weaker evidence of a cointegrating vector, which is consistent with observed market behaviour for *SSM*; they have tended to be a constant commodity flow (Figure 6.1) as part of domestic sawn softwood supply chain risk management (ABARES, 2025a). Even though the *SSM* specification was less tightly cointegrated than *AMESS*, the significant β_{SE} is consistent with theoretical expectations, and the significance of α_{DC} and β_{DC} matches observed relationships between the construction sector and *SSM* (ABARES, 2025a). The remaining tests confirmed the *SSM* specification is unbiased. Therefore, the signs of the significant coefficients can be interpreted with confidence; however, magnitudes should be interpreted with caution because of weaker cointegration.

Detailed diagnostic test results

The Reinsel-Ahn (RA) correction (Reinsel and Ahn, 1992) is a degrees-of-freedom adjustment to prevent the Johansen Test and Maximum Eigenvalue test from over-detecting cointegration in small samples. Given the model parameters (27 observations, 5 variables and 2 lags (a lag in first differences), the adjustment factor is 0.63 (i.e. a 37% small sample size penalty). The reported 95% critical values in the notes of Table A5 are the raw Johansen Test and Maximum Eigenvalue critical values multiplied by 0.63. In the case of *AMESS*, both the Johansen Trace statistic and the Maximum Eigenvalue test—each adjusted for finite-sample bias using the Reinsel-Ahn (RA, 1992) small-sample adjustment – identified one cointegrating vector ($r = 1$, $p < 0.05$). In the case of *SSM*, the Johansen Trace statistic was not significant; however, the Maximum Eigenvalue statistic was significant ($r = 1$, $p < 0.05$) after RA adjustment.

The dynamic stability of the cointegration was confirmed for the *AMESS* and *SSM* specifications with the eigenvalue stability test. In the outputs below, an earlier abbreviation for *AMESS* was used (non-sawn softwood imports, *NSSM*). Consistent with a five-variable system possessing a single cointegrating relationship, exactly four unit roots were identified. All remaining roots were found to lie strictly within the unit circle, ensuring that the VECM possesses a stable steady-state and that any exogenous shocks to the market trigger processes that converge the market toward the estimated long-run equilibrium, restoring the materials balance.

==
VECM DYNAMIC STABILITY REPORT for *AMESS*
==
Top 6 Eigenvalue Moduli:
Root 1: 1.00000 (Unit Root)
Root 2: 1.00000 (Unit Root)
Root 3: 1.00000 (Unit Root)
Root 4: 1.00000 (Unit Root)
Root 5: 0.72799 (Stable)
Root 6: 0.72799 (Stable)

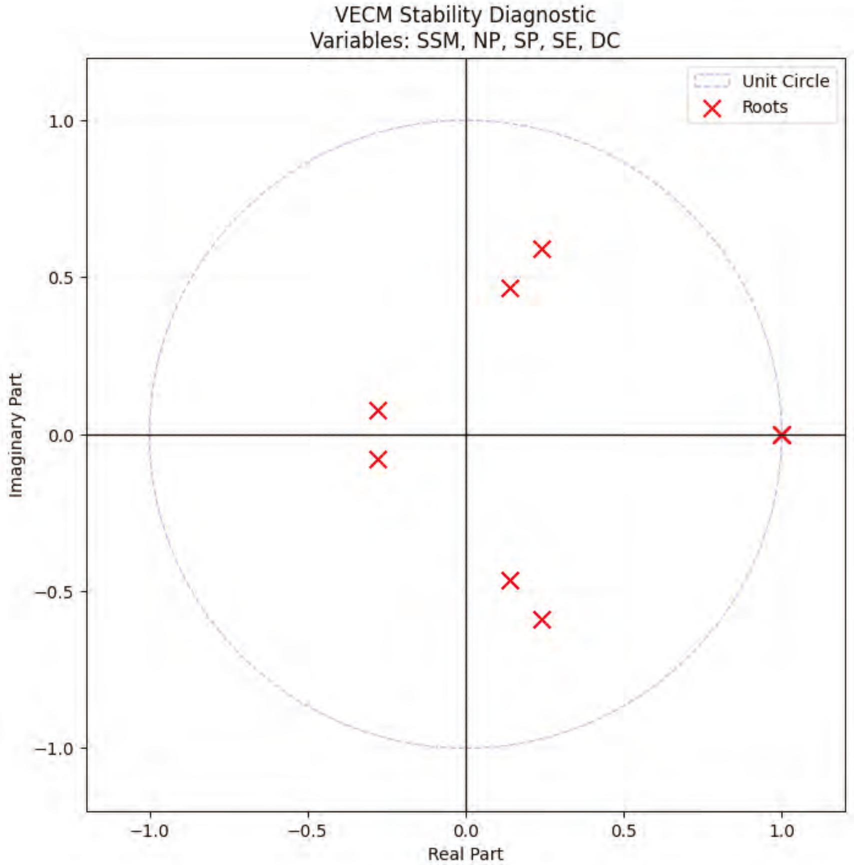


==

VECM DYNAMIC STABILITY REPORT for *SSM*

==

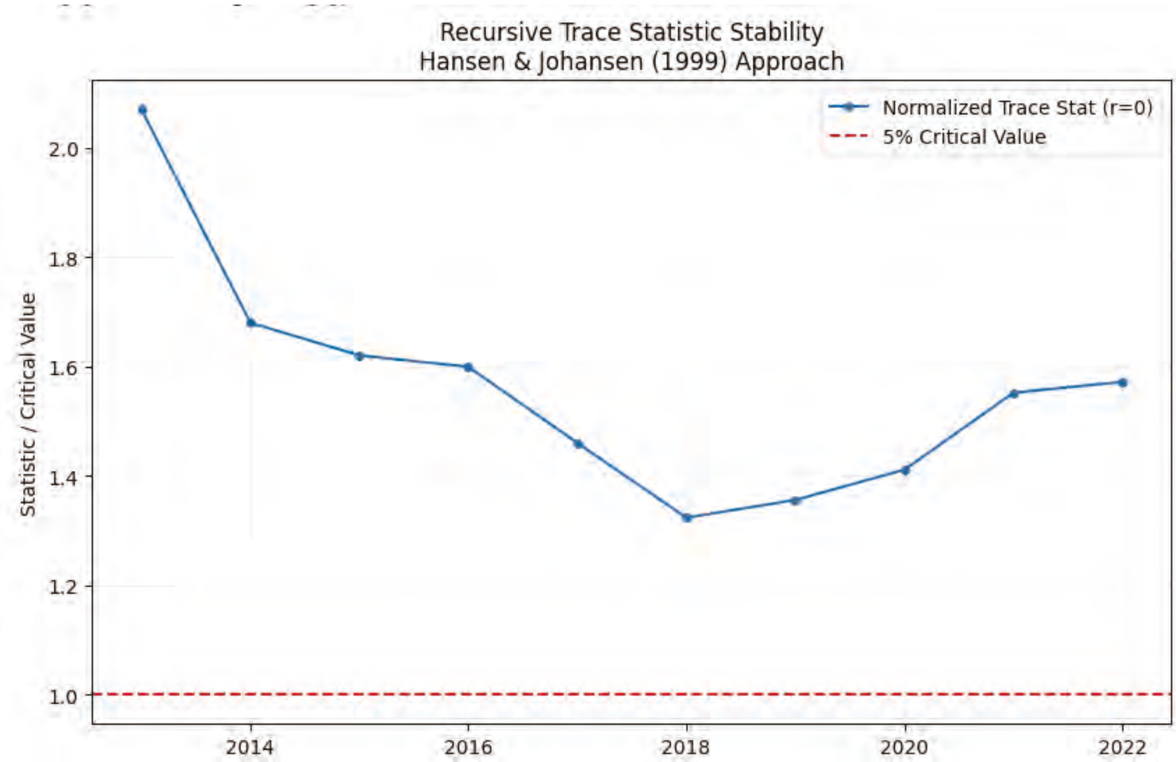
Top 6 Eigenvalue Moduli:
Root 1: 1.00000 (Unit Root)
Root 2: 1.00000 (Unit Root)
Root 3: 1.00000 (Unit Root)
Root 4: 1.00000 (Unit Root)
Root 5: 0.63761 (Stable)
Root 6: 0.63761 (Stable)



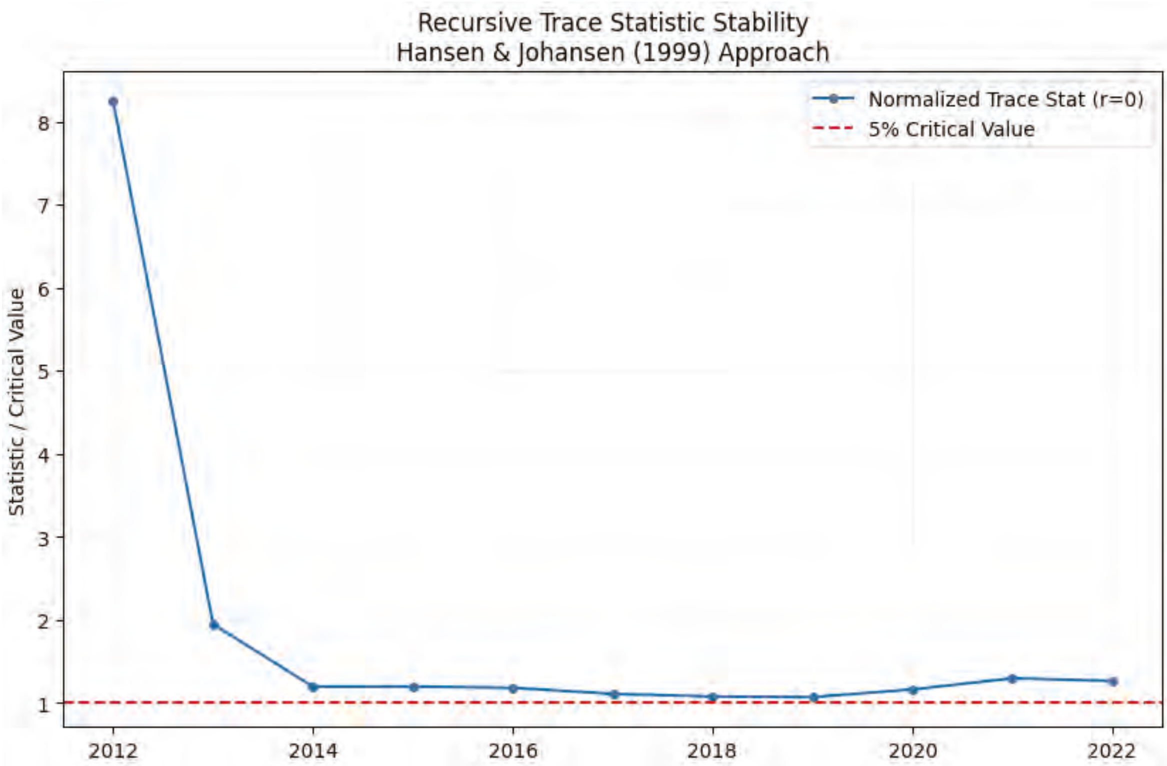
The Hansen & Johansen (1999) recursive estimation procedure revealed that the cointegrating relationship held over time as new annual data were added. The recursive trace statistic remained above the 5% critical value (>1.0) throughout the analysis period, including during the 2020–2022 period, despite the significant global logistics and domestic demand shocks associated with the COVID-19 pandemic. The persistence of the cointegrating relationship suggests the VECM specifications are both suitable for policy analysis.

Following Lutkepohl (2005), a non-parametric bootstrap procedure with 500 iterations was employed to generate an empirical distribution of the maximum eigenvalue statistic, which yielded an empirical *p*-value that accounted for the variance and covariance structure of the data. Cointegration is confirmed if the empirical *p*-value is less than 0.05 (solid red line is to the right of the yellow dotted line in the following figures). The *SSM* specification failed the bootstrapped maximum eigenvalue test, which does raise questions about the policy analysis suitability of the *SSM* specification.

===
AMESS RECURSIVE TRACE STATISTIC STABILITY
===



======================================
SSM RECURSIVE TRACE STATISTIC STABILITY
=======================================

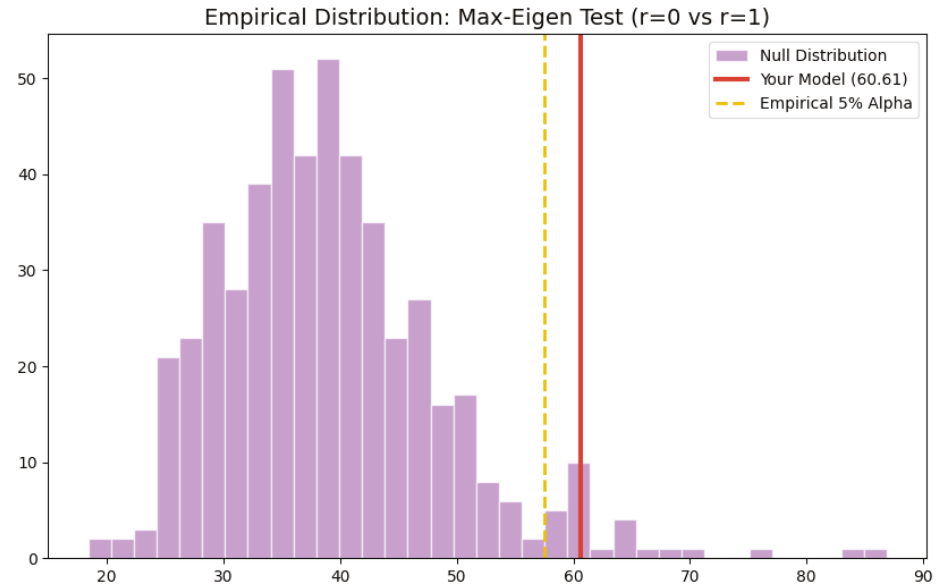


==

AMESS BOOTSTRAPPED MAXIMUM EIGENVALUE TEST

==

```
=======================================================
📈 MAX-EIGENVALUE BOOTSTRAP SUMMARY (N=27)
=======================================================
Observed Max-Eigen Stat (r=0): 60.6075
Empirical 95% Critical Value:  57.5395
Empirical P-value:             0.0260
=======================================================
```



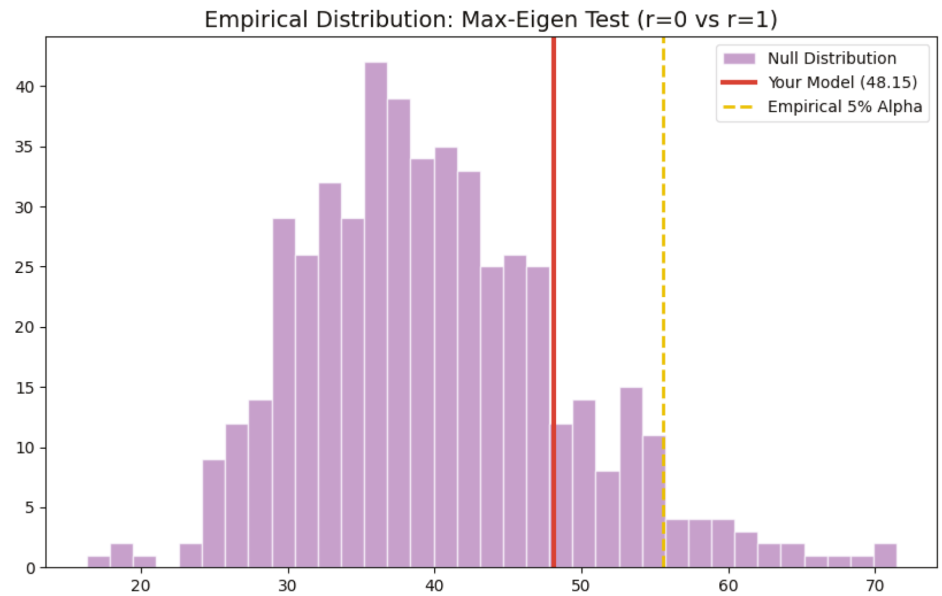

```
✅ SUCCESS: The Max-Eigen test confirms cointegration under bootstrap.
```

==

SSM BOOTSTRAPPED MAXIMUM EIGENVALUE TEST

==

```
=======================================================
📈 MAX-EIGENVALUE BOOTSTRAP SUMMARY (N=27)
=======================================================
Observed Max-Eigen Stat (r=0): 48.1518
Empirical 95% Critical Value:  55.5505
Empirical P-value:             0.1660
=======================================================
```




```
⚠️ WARNING: The result is not significant at the 5% level.
```

The Log-likelihood, AIC and BIC confirmed strong mathematical fit for the *AMESS* and *SSM* specifications. The residuals were found to exhibit no autocorrelation up to 10 lags (Ljung-Box). The near-perfect diagnostic *p*-values for autocorrelation ($p > 0.9$) are a strong indicator that no systematic economic drivers have been omitted that would bias the model. In addition, multivariate normality was confirmed via the Jarque-Bera test, and the multivariate ARCH-LM test indicated the absence of heteroskedasticity.

The VECM demonstrated robust explanatory power (R^2) in the short-run (Γ) equations, particularly for variables sensitive to domestic supply. As reported in Table A5, The model accounts for 80% to 90% of the annual volatility in dwelling commencements and 45% to 58% of the variation in timber imports. Given that these R^2 values are derived from a system in first differences (i.e. annual changes), they represent a high degree of fit relative to standard econometric benchmarks. This confirms that the models have successfully disentangled cyclical housing demand from the underlying structural substitutions between domestic production and imports. Lower R^2 values for native production, softwood production and softwood log exports (< 35%) were expected and reinforce the model's validity. Rather than being endogenous to domestic timber market prices and quantities demanded, annual harvest and log export fluctuations are governed by exogenous policy (e.g. native forest harvest closures and sustainable yield targets), biological (e.g. plantation rotations) and global trade (e.g. long-term contracts with ports, shipping companies and international buyers) factors.

The collective results of these diagnostic checks affirm the structural integrity of the models, providing a sound basis for simulating the long-run impacts of forest policy and projecting timber supply-chain dependencies. However, because the *SSM* VECM specification failed two out of five cointegration tests, magnitudes of coefficients from the *SSM* specification should be interpreted with caution because of weaker cointegration.

A.2.5 Interpretation of the VECM short-run coefficients (Γ) in the AMESS and SSM imports equation

All variables in the VECM were expressed in natural logarithms; thus, Γ represent short-run elasticities. That is, for the model specified by equations 1 to 3, they represent the short-run percent change in imports for a 1% change in the variable of interest. A negative Γ coefficient indicates short-run substitution effects. Conversely, positive Γ indicate the variable of interest is complementary to (i.e. moves together with) imports. Following the framework established by Engle and Granger (1987), causality in the VECM can be assessed through both the short-run lagged dynamics (Γ) and the loading coefficients (α); however, this study is focussed on the long-run adjustment of the market associated with α.

A concise interpretation of the short-run coefficients in the imports equation in Table A5 is provided here. The significant Γ constants have absorbed the unit-of-measurement differentials between timber volumes and dwelling commencements and represent a deterministic baseline macroeconomic drift rather than a behavioural parameter. Nonetheless, they indicate Australia's solid wood market has defaulted toward higher import volume as domestic supply has failed to keep pace with macroeconomic growth. The insignificance of lagged imports ($\Gamma_{AMESS}$and Γ_{SSM}) in explaining this years' imports suggests there is no inertia in imports – their level has responded to the gap between domestic supply and demand. The positive and significant coefficients for native forest sawlog production and softwood plantation sawlog production ($\Gamma_{NP}$and Γ_{SP}) in the *AMESS* specification indicate domestic production and imports are pro-cyclical. In an environment with high demand for dwelling commencements (*DC*), increased *NP* and *SP* last year tends to be associated with increased imports this year (e.g. ~2014 in Figure 6.1). The negative and significant coefficient for softwood log exports (Γ_{SE}) in *AMESS* and *SSM* model specifications indicates an increase in softwood log exports last year is associated with a decrease in imports this year, suggesting that, in the short-run, higher exports were associated with domestic softwood production levels that were surplus to domestic demand. The insignificance of Γ_{DC} suggests the demand pull from housing was either captured by Γ_{NP}, Γ_{SP} and Γ_{SE}, or the lead times for increases in imported timber to support expansion of housing starts was too long or too irregular for the short run equations (with a 'look back' period of two years) to detect a significant effect.

A.2.6 Additional policy-relevant findings from the VECM

Some of the interesting policy-relevant findings from the VECM analysis (Figure 6.2 and Table A5) were not described within the body of the report and are provided here.

The insignificance of α_{NP} and α_{SP} Indicated native forest and softwood plantation sawlog production have been on their own paths, independent of the timber market. *NP* has been in policy-driven decline since 1996-97. *SP* is likely better explained by the area of mature forest ready for harvest. Furthermore, Figure 6.1 highlighted that the area of the softwood plantation estate has not increased since 2001, therefore, there is limited capacity for the estate to increase *SP*.

The significant negative α_{DC} in both model specifications suggests a decline in *NP* and *SP* act as a direct constraint on the economy's long-term capacity to construct dwellings (*DC*). In the *AMESS* VECM specification, decreases in *NP* and *SP* structurally force a corresponding decrease in *DC*.

The β_{DC} are significant and negative in both VECM specifications, likely reflecting lower intensity of imported wood per dwelling commencement, not 'increased dwelling construction decreases imports'. This interpretation is consistent with changes in the composition of dwelling commencements over the study period, with rising proportions of apartments and townhouses relative to free-standing homes (ABARES, 2025e), and the loss of market share to non-timber substitutes with high embedded carbon, such as steel house framing (Houghton, 2023). The model may also be capturing technological shifts that have resulted in higher material efficiency over time relative to traditional 'stick' framing. Furthermore, *SP* rose substantially along with *DC* during the study period (Figure 6.1) such that *SP* per *DC* was greater than in 1996-97, except for the last two years analysed. This increasing source of domestic supply will have reduced the need to expand imports during the study period, and may be partly responsible for the negative β_{DC}.

In the *AMESS* VECM, *SP* is a structural forcing variable. A 100,000 m^3 RWE reduction in *SP* long-run structurally drives a contraction in complementary *AMESS* (-53,800 m^3 RWE), because reduced domestic softwood availability slows construction activity. Recall that *AMESS* and *NP* are complementary to *SP*.

In the *SSM* VECM specification, β_{NP} and β_{SP} are insignificant, indicating domestic supply has no long-run stable relationship with *SSM*. Therefore, long-run leakage from reduced *NP* and *SP* into increased *SSM* cannot be distinguished from 'statistical noise' and has been treated as zero for policy purposes. This suggests *SSM* have been demand-driven to fill domestic production shortfalls, rather than domestic supply driven. This interpretation is consistent with the observations that *SP* had been on its own exogenous increasing trend between 1996 and 2019 (Figure 6.1) as the plantation estate matured, and *NP* is not a substitute for *SP* or *SSM*.

In both model specifications, the significant positive β_{SE} indicates exports are pro-cyclical with domestic demand for imports; reduced *SE* is associated with reduced imports of *AMESS* and *SSM*. From Table S6, the long-run partial elasticities of *DC* with respect to *SE* in both models are positive ($AMESS\ \epsilon_{DC,SE} = -\left(\frac{0.3795}{-2.7346}\right) = 0.139$; $SSM\ \epsilon_{DC,SE} = -\left(\frac{0.6028}{-3.0566}\right) = 0.197$), which indicates a decrease in *SE* is associated with a decrease in domestic demand for solid wood, *DC*. Therefore, reduced *SE* has occurred during broader economic slowdowns, rather than diversion to domestic supply chains that reduced the need for imports.

A.3 Omitted variable bias tests for the Australian to US dollar exchange rate and relative price competitiveness of domestic versus imported wood product manufacturing costs

Many variables are likely to affect Australia's solid wood import volumes. However, the inclusion of additional endogenous variables such as the exchange rate and relative domestic versus imported manufacturing costs in a VECM framework with only 27 annual observations is statistically prohibitive. Degrees of freedom are rapidly depleted, leading to severe overfitting, loss of statistical power, and unreliable standard errors. Extensive testing revealed five variables (including the dependent variable) was the maximum that could be analysed while avoiding model 'over-fitting' with the data available for analysis. Selection of variables for the parsimonious model was informed by Lasso regression (see A.1.1).

Instead of adding a sixth variable, a two-step residual regression approach was employed. This allowed for rigorous testing of the exchange rate and relative domestic versus imported manufacturing costs as an exogenous shock without compromising the parsimony and stability of the five-variable model, ensuring that the results remain robust and interpretable. These regressions tested for omitted variable bias in the VECM. If residual regression coefficients were statistically significant, then leakage attributed by the five-variable VECM to reduced native forest harvest may actually be market responses to the exchange rate or relative domestic versus imported wood product manufacturing costs.

This section presents the data and residual regression analyses for the exchange rate and relative price competitiveness. For each omitted variable, the datasets and method for the residual regression analyses are described, and then the results of the omitted variable tests are interpreted.

A.3.1 Australian exchange rate: data and results from the omitted variable bias test

Figure A1 plots the average annual USD to AUD exchange rate (right axis, cents) over time with *AMESS* and *NP* (left axis, AU$1000s)*.* During this period, the average annual exchange rate varied between 52 and 104 US cents to the AUD (and dropped to an all-time low briefly in early 2000 to 47.8 US cents). Figure A1 does not reveal any clear AUD-*AMESS* trend; *AMESS* volumes rise when the AUD is lower and when the AUD is higher.

Figure A1. Average annual AUD to USD exchange rate, *AMESS* and *NP*, 1996-97 to 2022-23

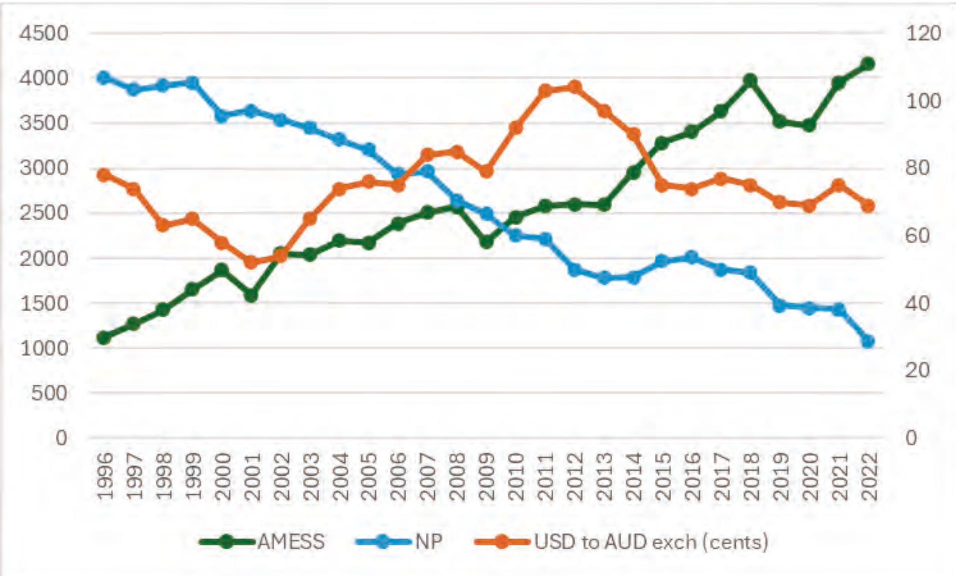


Figure A2 plots the annual change in *AMESS* against the annual change in the exchange rate. This better captures the short-term impacts of the exchange rate on imported wood volume[4]*.* As one would expect, it suggests a positive relationship (higher Australian dollar correlated with higher imports), with 2% of the annual change in *AMESS* explained by the annual change in the exchange rate; however, there are three outlier observations that help define this relationship, as indicated in Figure S9. When these outliers are removed, as in Figure A3, correlation remains low but the relationship is negative – Australia imports more when the exchange rate falls (and imports become more expensive), which is a counter-intuitive result.

A few comments on the outlier observations highlighted in Figure A2 are warranted. The Global Financial Crisis (GFC) and Covid-19 were global market shocks. The GFC had its origins in the US in 2007 with the subprime mortgage collapse. However, global impacts peaked in the second half of 2008 through 2009. The major

[4] An assessment was also made of the relationship between the AUD exchange rate and next-years' imports (i.e. a one-year lag in the impact of an exchange rate change on imports). The relationship was negative with an R^2 of 1.43%.

impact of the Covid-19 pandemic was over the period late 2019 through 2020. Each of these shocks severely impacted Australia's construction sector, as indicated by depressed dwelling commencement (*DC*) in Figure 6.1c. The introduction of Australia's 10% goods and services tax on July 1, 2000, was a domestic market shock that also caused a *DC* slump (see Figure 6.1c). Each of these three *DC* slumps dramatically reduced timber imports (see Figure 6.1d). In 2001, the federal government doubled the First Homeowner Grant and this rebounded *DC* levels by 2002.

Figure A2. Annual change in AMESS and annual change in the AUD exchange rate

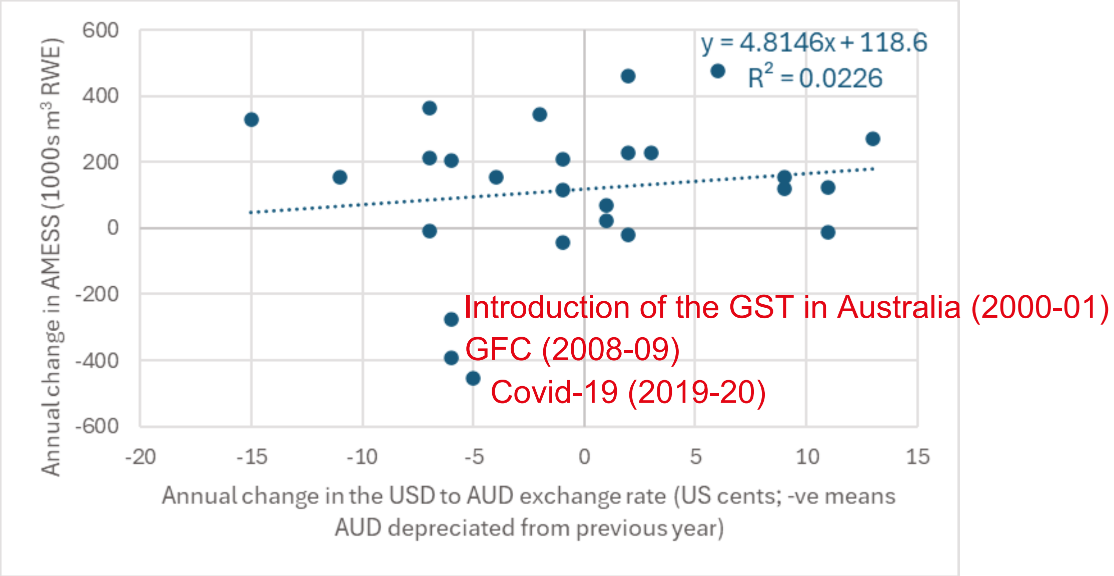
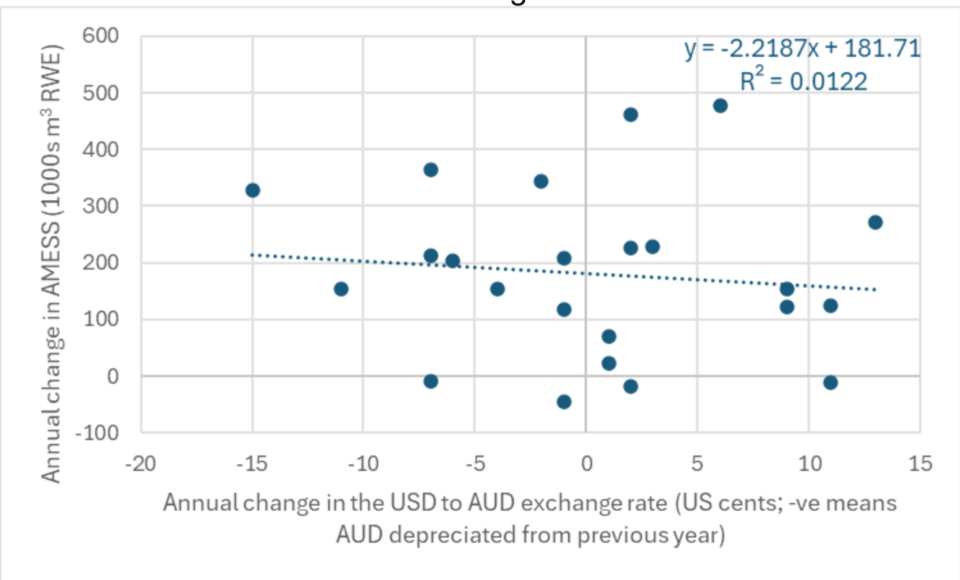


Figure A3. Annual change in AMESS and annual change in the AUD exchange rate with the three outliers indicated in Figure A2 removed

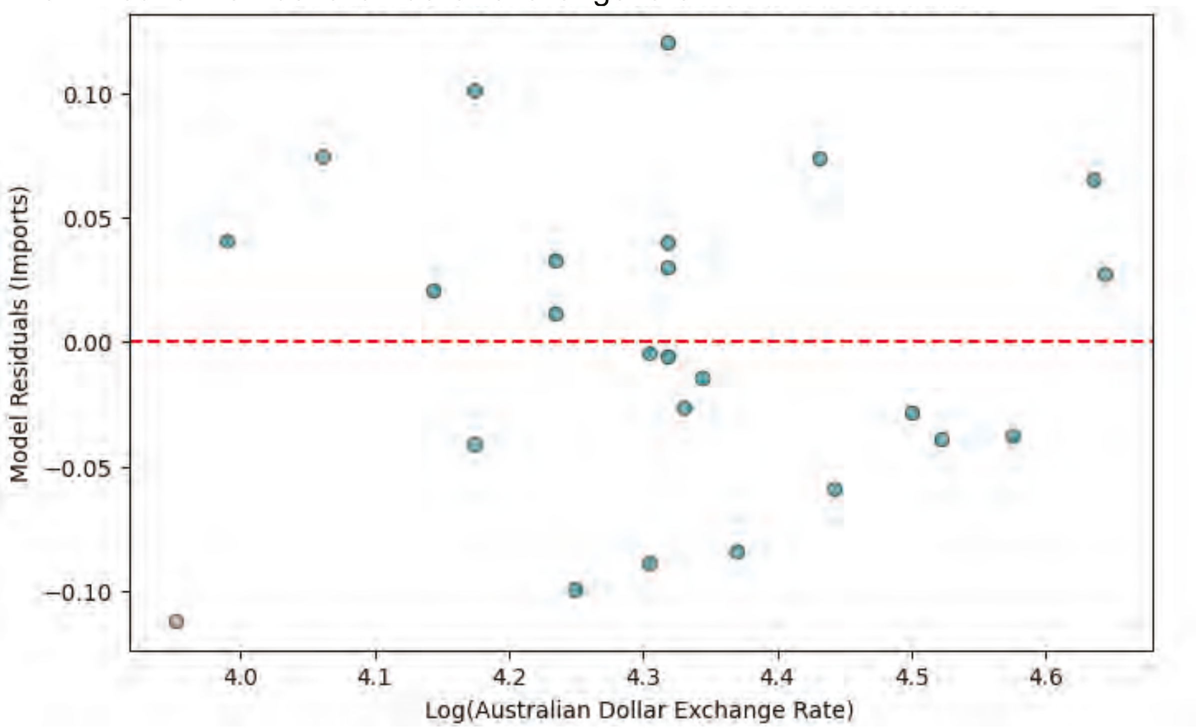


The VECM specification of interest is *AMESS*, which identified statistically significant and large international timber harvest leakage attributable to reduced native forest timber production. To address the hypothesis that the Australian dollar to US dollar exchange rate explains the residual variance in the *AMESS* VECM, a secondary OLS regression analysis was performed. The dependent variable in the secondary regression is the residuals (e_t, unexplained variation in import demand) from the *AMESS* VECM, which are, by definition, stationary. This was regressed against the first difference of the logged Australian-to-US dollar exchange rate (*XR*). This transformation ensures the series is stationary and allows for an elasticity-based interpretation of the impact of currency fluctuations on residual demand. The fitted model was:

$$e_t = \beta_0 + \beta_1[ln(XR_t) - ln(XR_{t-1})] + v_t$$

The regression yielded a β_1 coefficient of 0.0047 and *p*-value of 0.949 (critical value <0.05), confirming that there is no relationship between the VECM residuals and the Australian to US dollar exchange rate (exchange rate illustrated in Figure A4). Therefore, the 81.3% leakage estimate for reduced native forest harvesting has not been biased by omitted currency fluctuations. The test provides no statistical support for the hypothesis that currency fluctuations were a primary driver of import growth.

Figure A4. *AMESS* VECM imports residuals and the regression line (red dotted line) when fitted to the Australian dollar exchange rate

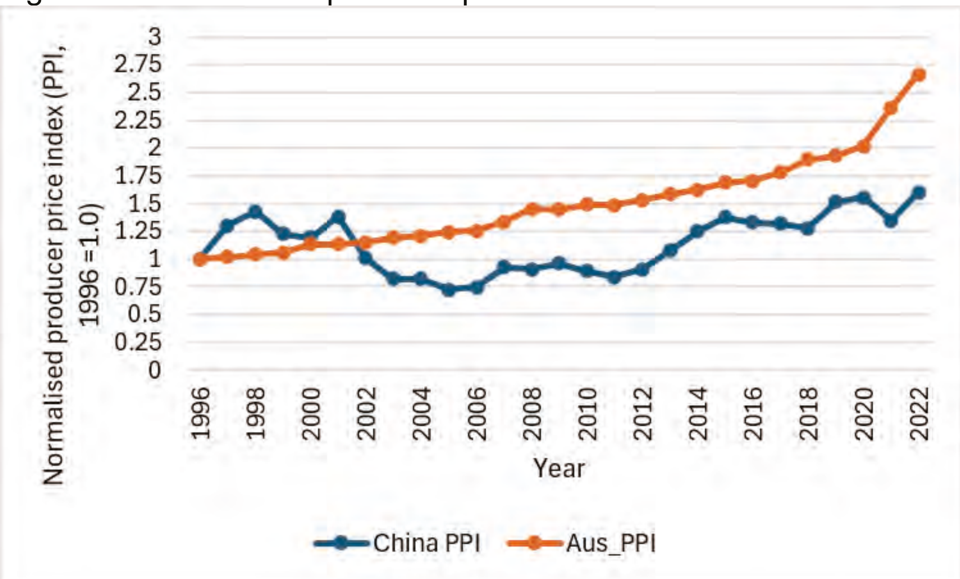


A.3.2 The relative price competitiveness of domestic versus imported wood products: data and results from the omitted variable bias test

Australian quarterly producer price index (PPI) data 1996 to 2022 for the wood products manufacturing sector is available from the Australian Bureau of Statistics (https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/producer-price-indexes-australia/latest-release; 14 Wood Product Manufacturing, accessed 27 May 2026). To be consistent with Australian production and trade data reporting, which is annual from July 1 to June 30 (e.g. 1996-97), PPI data was collected for the mid-point of each production and trade reporting year – quarter 4 (i.e. 31 December). For example, the PPI for 1996-97 was quarter 4 1996). Figure A5 reports Australia's wood product manufacturing PPI normalised to 1996-97 (i.e. Australian PPI 1996-97 = 1.0). Producer costs increased steadily from 1996 to 2020, followed by large increases in 2021 and 2022.

Since 1996-97, China has supplied 75.2% of the increase in Australia's *AMESS* imports. Therefore, manufacturing costs in China should adequately represent PPI for *AMESS* imports. However, a China wood product manufacture PPI is not readily available. A proxy for China wood product PPI has been developed using FAOSTAT China total export volume and value (US$) data (https://www.fao.org/Faostat/en/#data) for the period 1996 to 2022. Five large export categories had both export volume and value data – coniferous sawnwood and hardwood sawnwood, and the engineered wood product (EWP) categories of plywood and LVL, particleboard, and MDF[5].

Figure A5. Normalised producer price indices for Australia and China, 1996 to 2022



The annual export value for each product category was divided by the annual product volume for each category to generate an average US$ export price per cubic metre for each product category in each year. To account for currency exchange rates affecting Australia's purchasing power, the export prices for each product in each year were converted to Australian dollars with the average annual Australian dollar to US dollar exchange rate (Figure A1). This approximates the price at which Chinese product could be imported to substitute for Australian manufactures and is related to China's wood product manufacture PPI. For convenience, the Australian dollar export price per cubic metre for China's wood exports will be referred to hereafter as China PPI. A composite China PPI was then estimated for each year by calculating the average of the Australian dollar export prices for the five product categories. This was then normalised by setting the China PPI in 1996 equal to 1.0.

[5] Substantial import categories for Australia include builders' carpentry and wooden furniture; however, only export value data are available for these products from FAOSTAT. Nevertheless, sawnwood and engineered wood products are the material inputs to builders' carpentry and wooden furniture volume data; hence the derived average US$ export prices per cubic metre by product category are likely to provide reasonable proxies for changes in China PPI for these products.

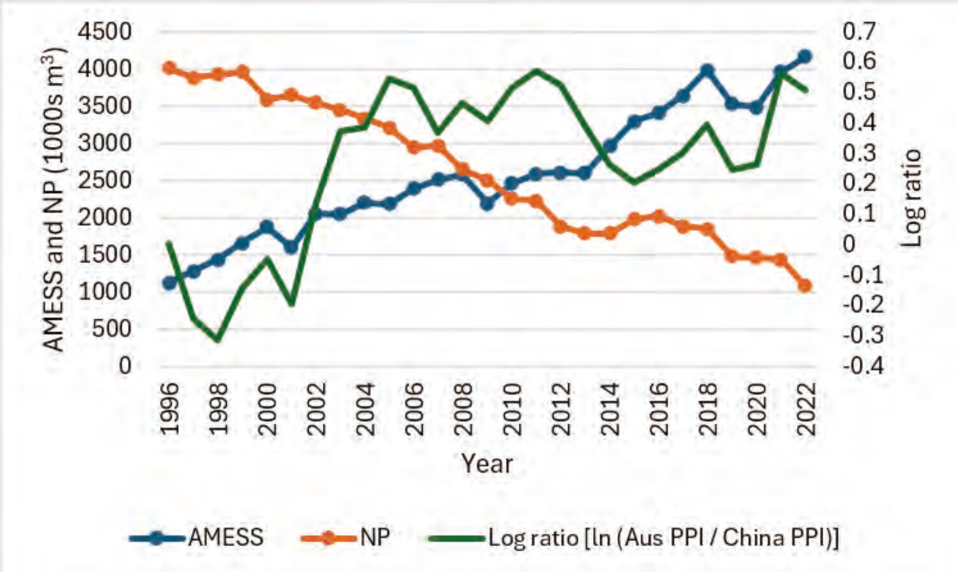
The normalised China PPI is illustrated in Figure A5. From 1996 to 2001, the China PPI grew faster than Australian PPI. Then, the efficiency of Chinese production improved dramatically such that China's increase in solid wood production costs throughout the period were considerably lower than in Australia.

To address the hypothesis that Australian PPI relative to China PPI explains the residual variance in the *AMESS* VECM, a secondary OLS regression analysis was performed. A new variable capturing the relative price competitiveness of Australian to Chinese wood products was calculated from the normalised PPIs in Figure A5. In economics, it is standard practice to use the natural logs of ratios because the math transforms the relationship into an elegant linear subtraction:

$$ln\left(\frac{Aus\ PPI}{China\ PPI}\right) = ln(Aus\ PPI) - ln(China\ PPI)$$

This log ratio (relative price competitiveness) is illustrated in Figure A6 with *AMESS* and *NP*. Negative log ratios indicate that Australian prices increased less than Chinese prices relative to 1996. Positive log ratios mean Australian prices increased more than Chinese prices relative to 1996. *AMESS* increased throughout the study period, with the slowest rate of increase surprisingly being when Australian wood product manufacturers were at their least competitive levels relative to Chinese imports (2002 to 2012).

Figure A6. The relative price competitiveness of Australian to Chinese wood products (ln(Aus PPI / China PPI)), and *AMESS* and *NP* for the period 1996 to 2022



The dependent variable in the secondary regression is the residuals (e_t) from the *AMESS* VECM, which are, by definition, stationary. However, Aus PPI and China PPI are non-stationary. Therefore, the residuals should be regressed against the first difference of the log-ratio, which represents the change in relative price competitiveness. Thus, the following regression was fitted to the data.

$$e_t = \beta_0 + \beta_1 \left[ln\left(\frac{Aus\ PPI_t}{China\ PPI_t}\right) - ln\left(\frac{Aus\ PPI_{t-1}}{China\ PPI_{t-1}}\right) \right] + v_t$$

The residual regression results in Figure A7 indicate that change in relative price competitiveness is a statistically insignificant predictor of the residuals (p = 0.122) and the R^2 of 0.1 (and adjusted R^2 0.06) indicates that only 10% (6%) of the residual variance from the *AMESS* VECM is explained by the regression. Therefore, the 81.3% leakage estimate for reduced native forest harvesting has not been biased by an omitted relative price competitiveness variable. The test provides no statistical support for the hypothesis that relative price competitiveness was a primary driver of import growth.

Figure A7. Regression results of *AMESS* VECM imports residuals against the relative price competitiveness

```
==============================================================================
Dep. Variable:                      y   R-squared:                       0.101
Model:                            OLS   Adj. R-squared:                  0.061
Method:                 Least Squares   F-statistic:                     2.571
Date:                Wed, 27 May 2026   Prob (F-statistic):              0.122
Time:                        20:15:31   Log-Likelihood:                 35.647
No. Observations:                  25   AIC:                            -67.29
Df Residuals:                      23   BIC:                            -64.86
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0043      0.012     -0.349      0.730      -0.030       0.021
0              0.1442      0.090      1.604      0.122      -0.042       0.330
==============================================================================
Omnibus:                        1.811   Durbin-Watson:                   2.062
Prob(Omnibus):                  0.404   Jarque-Bera (JB):                1.078
Skew:                           0.127   Prob(JB):                        0.583
Kurtosis:                       2.015   Cond. No.                         7.43
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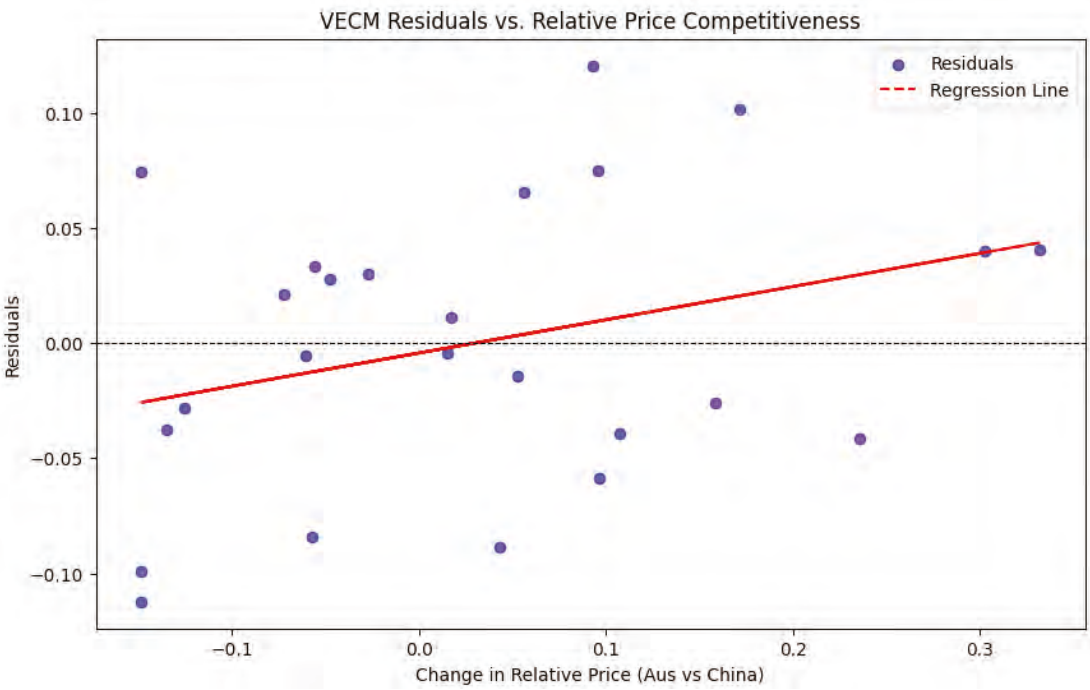


A.4 Additional details about the China solid wood supply chain analysis

A.4.1 Harmonised Tariff Item Statistical Codes (HTISC) analysed within the China trade database to estimate export volumes to Australia and their international forest footprint

The General Administration of Customs of the People's Republic of China trade database (available at http://stats.customs.gov.cn/) was queried by Harmonised Tariff Item Statistical Codes (HTISC) to identify the volume and value of all solid wood products exported to Australia for the period 2018 to 2023. The HTISC examined for non-furniture products are listed in Table A6. The furniture HTISC codes listed in Section A.1.2 directed analysis of China's furniture exports to Australia through The General Administration of Customs of the People's Republic of China trade database (available at http://stats.customs.gov.cn/).

Table A6. Non-furniture solid wood products included in analysis of China's exports to Australia by Harmonised Tariff Item Statistical Code

HTISC 4-digit	Description
4407	Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm.
4408	Sheets for veneering, incl. those obtained by slicing laminated wood, for plywood or for other similar laminated wood and other wood, sawn lengthwise, sliced or peeled, whether or not planed, sanded, spliced or end-jointed, of a thickness of ≤ 6 mm
4409	Wood, incl. strips and friezes for parquet flooring, not assembled, continuously shaped tongued grooved rebated chamfered V-jointed beaded moulded rounded or the like" along any of its edges ends or faces whether or not planed sanded or end-jointed"
4410	Particle board, oriented strand board (OSB) and similar board (for example, waferboard) of wood or other ligneous materials, whether or not agglomerated with resins or other organic binding substances.
4411	Fibreboard of wood or other ligneous materials, whether or not bonded with resins or other organic substances.
4412	Plywood, veneered panels and similar laminated wood.
4413	Densified wood, in blocks, plates, strips or profile shapes
4414	Wooden frames for paintings, photographs, mirrors or similar objects.
4415	Packing cases, boxes, crates, drums and similar packings, of wood; cabledrums of wood; pallets, box pallets and other load boards,of wood; pallet collars of wood.
4416	Wood casks, barrels, vats, tubs and other coopers' products and parts thereof, of wood, including stave
4417	Tools, tool bodies, tool handles, broom or brush bodies and handles, of wood; boot or shoe lasts and trees, of wood

4418	Builders' joinery and carpentry of wood, including cellular wood panels, assembled flooring panels, shingles and shakes.
4419	Tableware and kitchenware, of wood.
4420	Wood marquetry and inlaid wood; caskets and cases for jewellery or cutlery, and similar articles, of wood; statuettes and other ornaments, of wood; wooden articles of furniture (excluding furniture, lighting fixtures and parts thereof)
4421	Other articles of wood.

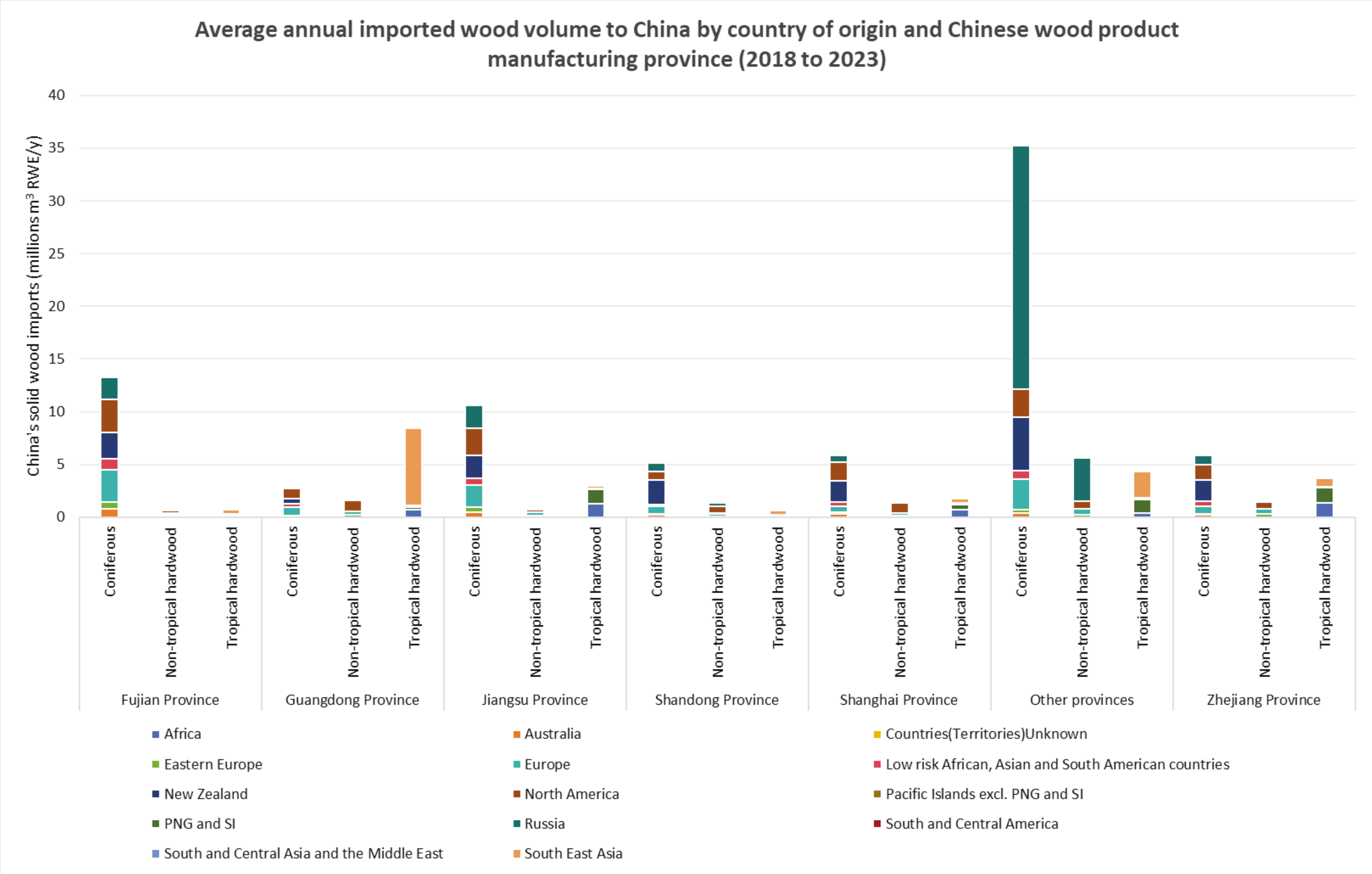
A.4.2 China provinces that export wood products to Australia, and the country of origin of China's imported feedstocks by province (2018 to 2023)

Table A7 and Figure A8 highlight that 91% of China's exports to Australia come from six out of a total of 31 timber processing provinces in China. These six provinces have much lower proportions of high and medium-risk coniferous and temperate (non-tropical) hardwood in their supply chains than the 'other' provinces. About 66% of China's coniferous and temperate hardwood imports to other provinces was sourced from Russia. Data are available from The General Administration of Customs of the People's Republic of China trade database (available at http://stats.customs.gov.cn/).

Table A7. The proportion of China's solid wood exports to Australia by province and the proportion of China's imports to those provinces

China province	% of exported wood volume to Australia	% of imported wood volume to China
Fujian	21.0	12.1
Guangdong	3.9	9.5
Jiangsu	32.2	13.5
Shandong	14.2	6.7
Shanghai	7.9	8.5
Zhejiang	11.8	11.0
Other	9.0	38.7
Total	100.0	100.0

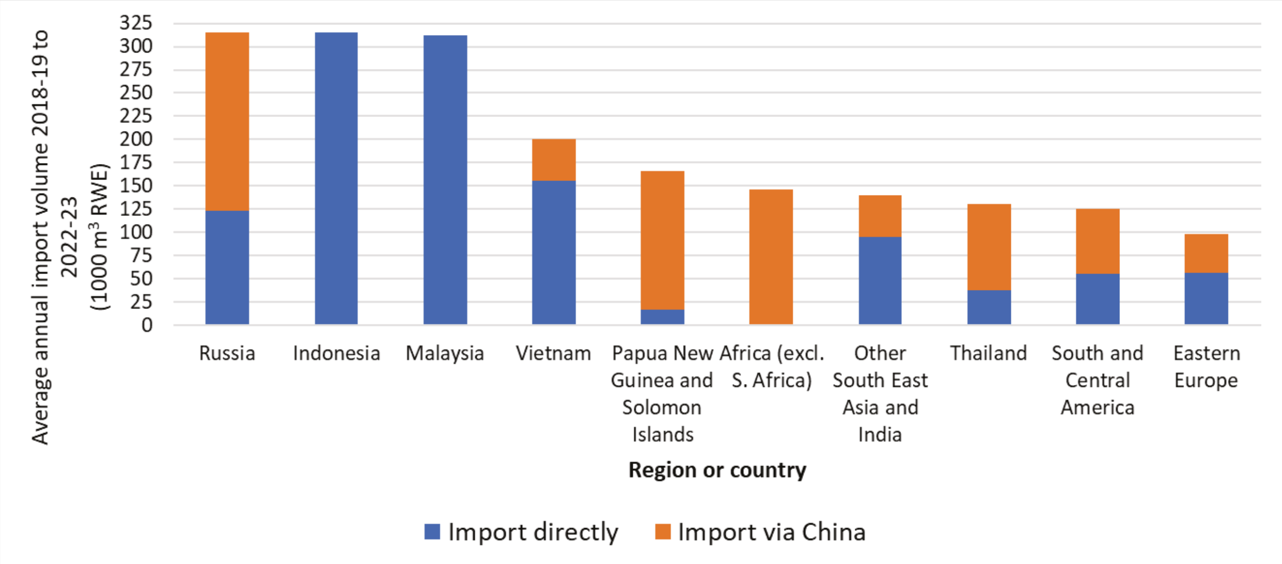
Figure A8. China's import volumes by country of origin to provinces that export to Australia



A.4.3 Australia's average annual elevated-risk imports (2018-19 to 2022-23) from bilateral and multilateral (via China) trade data

China's record of mean annual exports to Australia (Figure 5.9, panel b) was within 1.1% of Australia's record of mean annual imports from China for the period 2018-19 to 2022-23, at 1.79 M m^3 RWE/y. Of this, 0.78 M m^3 RWE is likely to have contained high- or medium-risk wood. Figure A9 summarises the direct and indirect (via China) mean annual imports of elevated-risk solid wood products (2018-19 to 2022-23) by country or region of origin, which totalled 1.95 M m^3 RWE/y. These imports are also illustrated in Figure 5.10.

Figure A9. Mean annual imports of elevated-risk solid wood products by country or region of origin, (2018-19 to 2022-23)



Note: From 2022, sanctions were placed on Australia's bilateral timber trade with Russia. However, there is risk that Australia continues to consume Russian timber via trade with China.

A.5 Calculation of Australia's elevated-risk forest harvest area footprint

Table A8 summarises calculation of Australia's annual harvest area footprint in elevated-risk nations. These areas were illustrated in Figure 6.3.

Table A8. Australia's annual harvest area footprint in countries or regions with elevated-risk, 2018-19 to 2022-23

High or medium-risk country or region	Annual import volume (1000 m^3 RWE/y)		Harvest volume per hectare (m^3 RWE/ha) [b]		Annual harvest area (ha) [c]		
	Native forest	Plantation forest	Native forest	Plantation forest	Native forest	Plantation forest	Total
Africa	145.9		36.5		4000		4000
Indonesia [a]	236.7	78.1	33.2	160	7100	500	7600
Malaysia [a]	210.3	101.8	40.8	200	5200	500	5700
Papua New Guinea	97.7		17.5		5600		5600
Russia [d]	314.8		184		1700		1700
Solomon Islands	70.7		28.3		2500		2500
Subtotal	1076.2	179.9			26,100	1000	27,100
Rest of world [e]	691.6		46.4		14,900		14,900
Total	1947.7						42,000

Notes: a. Imported sawn hardwood and builders' carpentry are produced from native forest hardwoods in Indonesia (168,800 m^3 RWE/y) and Malaysia (112,800 m^3 RWE/y). Plantations in Indonesia and Malaysia are primarily short rotation for pulpwood, but some produce logs for EWP manufacture. In the absence of better information, 50% of total volume of imported EWP (Indonesia 112,300 m^3 RWE/y; Malaysia 132,300 m^3 RWE/y) and furniture (Indonesia 33,700 m^3 RWE/y; Malaysia 67,000 m^3 RWE/y) was assumed to be from plantations. Product category import volumes derived from ABARES (2024a) and ABS (2024a), and native versus plantation wood mixes were informed by Indonesian and Malaysian sources (Ministry of Investment Trade and Industry, 2015; Ratnasingam et al., 2016; Hii et al., 2017; Ratnasingam et al., 2020).

b. Plantations are clearfall harvested, but selection harvesting is practiced in all native forests, except in Russia, where clearfall harvesting is practiced. Sources of harvest volumes per hectare are: Africa (Umunay et al., 2019), Indonesia (Jati et al., 2018; Hardiyanto et al., 2024), Malaysia (Pang et al., 2015; Ratnasingam et al., 2022), Papua New Guinea (Keenan et al., 2005; Yosi et al., 2011), Russia (FAO, 2012; Shvarts et al., 2023), and Solomon Islands (Wairiu, 2007).

c. Import volume divided by harvest volume per hectare and rounded to the nearest 100 ha.

d. From 2022, sanctions were placed on Australia's bilateral timber trade with Russia. However, there is risk that Australia continues to consume Russian timber via trade with China.

e. Elevated-risk imports from the rest of the world consisted of other Southeast Asian nations (68%, principally Vietnam and Thailand), South and Central America (18%) and Eastern Europe (14%). Harvest volume per hectare was approximated with the weighted average of the native and plantation forest harvest volumes of the countries and regions listed in the table.

A.6 Lower-bound estimate of Australia's hardwood imports in 2022-23

The authors are not aware of any useful published estimates of Australia's total hardwood import volume. Available estimates typically only include sawn hardwood, and ignore Australia's builders' carpentry, wooden furniture and plywood imports, which are predominantly hardwoods from tropical developing countries. FAO et al. (2020) reported the proportion of sawn wood and plywood production that is hardwood, with selected countries indicated in Table A9.

Table A9. FAO et al. (2020) proportion of domestic production that is hardwood

Country or region	% of sawn wood	% of plywood
China	32	75
Indonesia	98	99
Malaysia	100	100

In addition to sawn hardwood imports, other Australian import categories that include substantial quantities of hardwood are summarised in Table A10. Please note, the large import category 'Miscellaneous Other' (described at end of this section) has been excluded because it is challenging to determine the fraction of this category that is hardwood. Product categories 2 to 4 in Table A10 will include some softwood, but as described below, are mostly hardwood. As illustrated in Figure 5.7, most of product types 2 to 4 are supplied to Australia by China and developing countries in Asia, where hardwood proportions in domestic production are high. Australia's aggregate annual import of product types 1 to 4 has increased 380% since 1996-97.

Table A10. Australian imports with hardwood

Product category	1996-97 total import volume (m^3 RWE)	2022-23 total import volume (m^3 RWE)	% of 2022-23 volume supplied by China and tropical developing countries
1. Sawn hardwood	269,000	169,000	68%
2. Builders' carpentry (e.g. decking, flooring, mouldings, joinery, frames, doors, and staircases)	147,000	651,000	66%
3. Wooden furniture (including kitchen and bathroom cabinetry)	178,000	1,101,000	92%
4. Plywood (major engineered wood product category)	75,000	1,294,000	77%
Total	669,000	3,215,000	79%

Sources: Adapted from ABARES (2024a) and ABS (2024a).

Sawn wood and plywood are the main wood feedstocks for builders' carpentry and wooden furniture. Builders' carpentry and wooden furniture produced in Indonesia, Malaysia and Vietnam are manufactured from sawn hardwoods and hardwood plywood (ITTO, 2025). The proportion of builders' carpentry exported from China that is hardwood is unknown (because China is a major global timber aggregator and has no requirements for traceability), but is believed to be high (ITTO, 2025). Furniture exports from China are known to almost entirely include hardwood (ITTO, 2025; USDA Foreign Agricultural Service, 2026).

Based on the evidence in Table A9 (% of product that is hardwood), Table A10 (total impot volumes) and Figure 5.7 (proportion of imports by country of origin), Australia's hardwood imports in 2022-23 were estimated to be at least 2,338,000 m^3 RWE, as indicated in Table A11. This excludes hardwood volume that might be in imports of builders' carpentry, wooden furniture and plywood from developed countries, as well as 'Miscellaneous Other' imports, and therefore represents a lower-bound estimate. Even in the unlikely scenario that all the 1996-97 import volume in Table A10 was hardwood (likely to be some softwood, thus increasing the % change), Australia's hardwood imports have risen by at least 249% [(2,338,000 – 669,000)/669,000] since 1996-97.

Table A11. Preliminary and lower-bound estimate of hardwood timber volume in Australia's imports in 2022-23

Product category	Import volume by country or region (1000s m^3 RWE)					
	China	Indonesia	Malaysia	Other tropical developing	Low-risk countries	Total
Sawn hardwood	14	11	53	36	55	169
Builders' carpentry	171	159	66	36	197	651 [a]
Wooden furniture	747	35	69	157	93	1101
Plywood	790	115	49	54	285	1294 [b]
Total imports [d]	1722	320	237	282	629	3215
Total imports with hardwood [e]	1445	319	237	282	55 [c]	2338

Notes: a. Includes import volume from Russia. Further research is required to estimate fraction of builders' carpentry from Russia and low-risk countries that is hardwood.

b. Includes imports from Romania. Further research is required to estimate fraction of plywood from Romania and low-risk countries that is hardwood.

c. Only sawn hardwood imports is included in this sum of low-risk countries (consisting of predominantly New Zealand, North America and Western Europe). Further research is required to estimate fraction of hardwood in builders' carpentry, wooden furniture and plywood from low-risk countries.

d. Sum of the four product categories above.

e. Sawn hardwood is hardwood. Effectively all wood furniture from China and tropical developing countries is assumed to contain hardwood (ITTO, 2025; USDA Foreign Agricultural Service, 2026). Quantity of hardwood plywood was estimated as the proportion in Table A9 multiplied by the volume in Table A11. Proportion of hardwood in builders' carpentry imports was estimated as the average of the fractions of sawn wood and plywood that was hardwood (from Table A9), multiplied by the volumes in Table A11. Other tropical developing countries from which Australia directly imports wood products (mostly Vietnam and Thailand) have been assumed to have the same hardwood proportions as Malaysia (Table A9).

The 'Miscellaneous Other' wood products category includes all other wood products that do not fit into traditional categories. The 2022 import value of this category was $649 million and included items such as wooden tableware and kitchenware, wooden statuettes and ornaments, wooden frames (e.g. for paintings and photographs), wood marquetry and inlaid wood, wooden caskets, cases, boxes and crates, wooden coffins, coopers' products, wooden tools and tool handles, wooden clothes hangers, and wooden shuttering for concrete construction work.

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