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Market Integration of Domestic Wood and Imported Wood in Japan: Implications for Policy Implementation

Yoshihiko Aga

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Executive Summary

Japan has been one of the largest importers of wood products in the world. However, a large area of domestic plantation forests has matured, and the Japanese government has adopted several policy measures aimed at increasing the supply of, and demand for, domestic wood. The Forest and Forestry Revitalization Plan aims to increase the domestic wood supply and increase Japan's wood self-sufficiency rate to 50% by 2020. The potential effect of the Revitalization Plan on the Japanese wood market, should be understood based on the competitive situation and substitutability of domestic and imported wood.

This study examined the existence of a cointegration relationship between domestic and imported wood using sawlog and lumber price data. If both woods compete in a single Japanese market, then the law of one price, the necessary condition for substitution between imported and domestic wood to occur, must hold. Markets are said to be integrated if, at equilibrium, the law of one price (LOP) holds and no arbitrage opportunity exists as a necessary condition for price efficiency. If the LOP is upheld then trade models that assume price equilibrium among homogenous products can be used to study the effects that the Revitalization Plan would have on the volume of domestic and imported wood consumed in Japan. On the other hand, if the LOP does not hold to be true, then the assumption of these trade models is violated, and any results yielded by those trade models may not be correct.

Using Johansen's multivariate cointegration tests, it was revealed that the domestic wood market and the imported wood market had no cointegrating relationships. It was concluded that the market for domestic wood and that of imported wood are not closely connected through price arbitrage and that a price change for one wood product would not necessarily affect the prices of other wood products directly. Thus, the Revitalization Plan might not have a direct effect on the demand for imported wood products. However, in the case where the demand for wood remains constant or declining (as is the case in Japan), it is likely that a substantial increase in the demand for domestic wood would necessarily result in a corresponding decrease in the demand for imported wood.

Perhaps more importantly, the combined impact of the subsidy programs targeted towards the forestry and wood products sectors in Japan will likely adversely impact the demand for imported wood. In this regard, several issues have to be pointed out. First, Japanese housing starts have been decreasing and they are not expected to dramatically increase given that the Japanese population is aging and shrinking. Since lumber demand is highly dependent on the housing industry, the declining trend of housing starts will reduce the total demand for wood in Japan. Given the emphasis of the Revitalization Plan on doubling the supply of domestic wood by 2020, this will inevitably lead to a reduced demand for imported wood.

Second, as log imports decline, domestic sawmills and plywood mills have been switching from imported to domestic logs. This trend is strengthened by the government subsidy programs that support the expansion and modernization of domestic sawmills and plywood mills to replace older processing equipment with newer, more efficient processing technology that can utilize smaller diameter domestic logs. Thus, the share of imported logs used in domestic sawmills and plywood mills is likely to decline.

Third, Japanese macroeconomic policy affects wood imports. Recent monetary-easing measures have impacted the exchange rate by depreciating the value of the yen by almost 50% since Prime Minister Abe's election in December 2012. The depreciation of the yen as a result of Japan's change in monetary policy is likely to lead to a decline in total wood imports into Japan.

Finally, and potentially most importantly, other government subsidy programs targeted to expand the use of domestic wood may distort the market relationships found in this study. In early 2013, MAFF announced a plan to introduce the "Wood Use Points Program (WUPP)" which provides a substantial subsidy to homebuilders who use domestic wood in place of imported wood in the homes they build. If this program is successful, then the huge subsidies provided by the program would effectively expand the demand for domestic wood and the adverse impact of the WUPP Program on the demand for imported wood could be tremendous.

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Introduction

Background

Historically Japan has been one of the largest importers of wood products in the world. Wood imports increasingly have reduced the share of domestic wood since the 1960s, when the Japanese government liberalized wood imports by removing tariffs on most wood products in order to meet the skyrocketing demand for wood. Wood self-sufficiency in Japan plunged from over 90% in the 1950s to below 50% by the end of 1960s; declining to a low of 18.2% in 2002.

Meanwhile, a large area of domestic plantation forests planted in the post-war period has matured, reaching a harvestable age of over 50 years old. Since the early 2000's, as the domestic timber resource has continued increasing, the Japanese government has adopted several policy measures aimed at increasing the supply of, and demand for, domestic wood.

The most recent initiative includes the Forest and Forestry Revitalization Plan (hereafter referred to as "the Revitalization Plan") developed in 2009 by the Ministry of Agriculture, Forestry and Fisheries (MAFF), which aims to increase the domestic wood supply and achieve a wood self-sufficiency rate of 50% by 2020 through a combination of reforms and subsidies designed to expand timber supply and increase the use of domestic wood in construction (Eastin, 2011). Corresponding to the development and implementation of the Revitalization Plan, several concerns have been raised about the policy's effect on the competitiveness of imported wood in the Japanese market. Eastin and Sasatani (2014) point out that the Revitalization Plan could have a serious adverse impact on the competitiveness of U.S. wood products in Japan and undermine the ability of U.S. manufacturers and exporters to compete in Japan.

The potential effect of the Revitalization Plan on the Japanese wood market, however, should be understood based on the competitive situation and substitutability of domestic and imported wood. Without a sound understanding of the relationship between these domestic and imported wood, any preliminary conclusions regarding the effects could be misleading. Thus the objective of this study is to understand the competitive relationship between domestic and imported wood in the Japanese market, and subsequently to make inferences on the impacts of the Japanese Revitalization Plan on domestic and imported wood markets.

Overview of Japan's economy and wood demand

Japan's wood demand has been affected largely by its domestic economic situation. It is closely tied to domestic housing starts, which is the largest end-use demand sector for lumber (MAFF, 2011a). Japan's economy has changed greatly since World War II, and this economic performance can be divided largely into three periods characterized by different economic growth trends.

In the first economic period, 1956 to 1973, the average annual GDP growth rate in Japan was 9.2 % (Figure 1). This was a period of high economic growth and rapidly expanding timber demand. Timber demand skyrocketed from 45 million cubic meters (in log-equivalent volume) in 1955 to a record high of 117 million cubic meters in 1973. The rapid increase in timber demand was driven by a huge demand increase across all sectors of the economy including lumber for housing construction and infrastructure, lumber and plywood for civil engineering works, and pulp and chips for paper production (Figure 2).

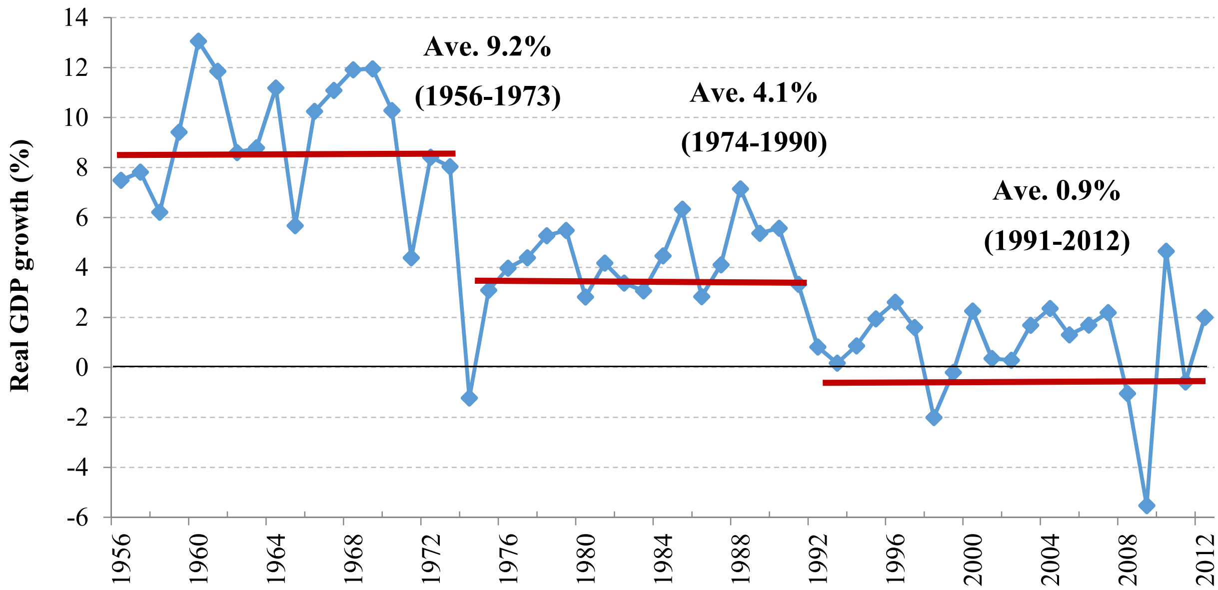

Figure 1. Japan's annual real GDP growth rate.
Source: Cabinet Office, 1998 (for 1956-1980), 2009 (for 1981-1994), 2011(for 1994-2011), 2013(for 2012)

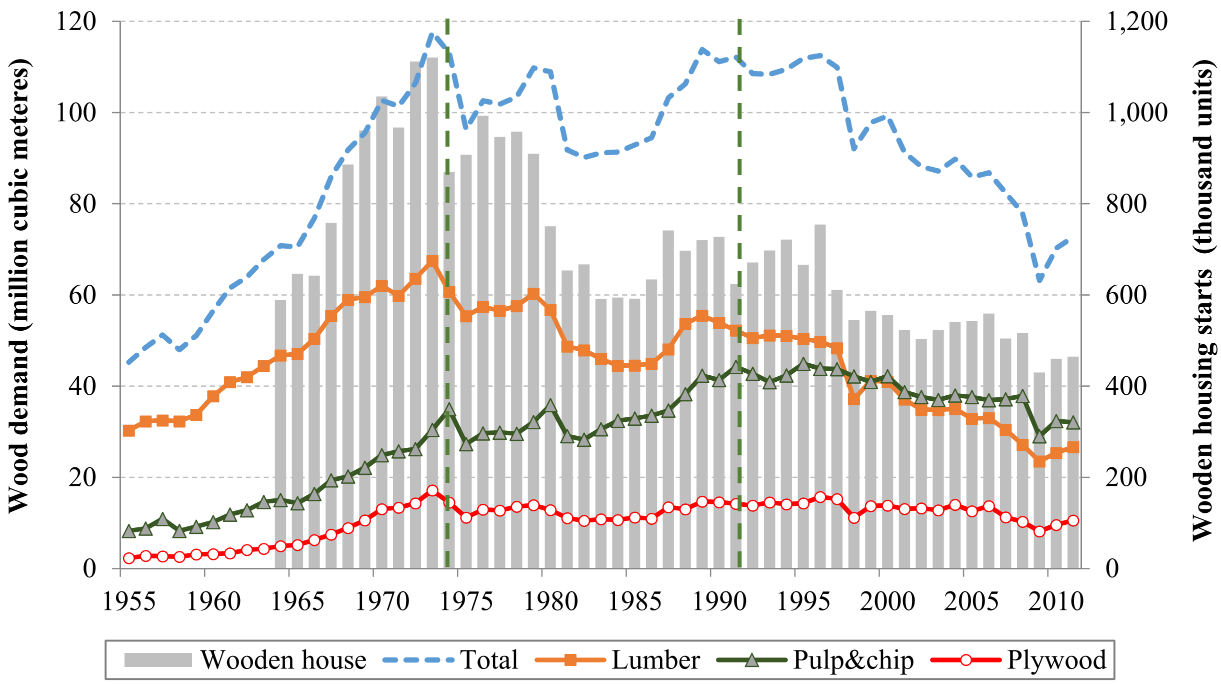

Figure 2. Wood demand (in log-equivalent volume) by application and wooden housing starts in Japan.
Source: Forestry Agency, 2012; MLIT, 2011

During the second economic period, two consecutive oil shocks in the early and late 1970s substantially damaged the economy and shifted the economic growth rate downward. Despite this, Japan's economy maintained moderate growth with an average annual GDP growth rate of 4.1% between 1974 and 1990.

The moderate growth could be partly attributed to the so-called bubble economy era spanning the period 1986 to 1990, which was primarily caused by the yen's appreciation against the U.S. dollar after the Plaza Accord in 1985. The appreciation of the yen, which caused economic damage to Japan's exporters, led the Bank of Japan to lower interest rates in an attempt to stimulate the economy. As a result people began to invest more in real estate, which led to higher levels of construction activity. It is against this backdrop of increasing demand for housing construction that wood demand, which had weakened following the oil shocks, began to recover. Wood demand increased by almost 20% during the bubble economy, jumping from 95 million cubic meters to 114 million cubic meters.

The third economic period began when Japan's economic bubble burst in 1990 triggered by a sharp decline in stock prices on the Tokyo Stock Exchange. The subsequent decade is referred to as the Lost Decade since the Japanese economy began to deteriorate during this time. Despite this economic crush, wood demand in the early 1990s remained relatively high thanks to a still increasing demand for pulp and chips, although the demand for lumber continued to decrease as housing starts declined. The sluggish economy was worsened by the increase in a consumption tax rate from 3% to 5% and by the Asian Financial Crisis, both of which happened in 1997. Wood demand plunged after 1997 as new housing starts experienced a huge decline, since people rushed to buy houses before the tax increase occurred and subsequently stayed away from home purchases afterward (Sasatani et al. 2010).

It has been said that the Lost Decade turned into Lost Two Decades, as low economic growth continued throughout the 1990s and into the first decade of the 2000s. Although Japan's economy recovered somewhat between 2002 and 2007, with over 2% annual GDP growth rate, it again entered into a recession after being hit by the global financial crisis in 2008. The recovery from the crisis, which coincided with a change in government from the Liberal Democratic Party (LDP) to the Democratic Party of Japan (DPJ) after the general election in 2009 brought about some increase in Japan's economic growth. However, the Tohoku Earthquake in 2011 and the Fukushima Dai'ichi Nuclear Plant disaster greatly affected subsequent economic growth. During the most recent decade, gross demand for wood showed a steeper downward trend than the previous decade, although the recovery from the financial crisis contributed to some increase in demand after 2010.

Wood supply and self-sufficiency

The liberalization of wood imports in the 1960s adversely affected Japan's domestic forestry sector in the subsequent decades. The supply of domestic wood continued to decline from the middle of the 1960s as it was replaced by imported wood. The increased demand for wood observed in the high economic growth period was almost entirely absorbed by an increase in imported wood. Eventually, self-sufficiency, which is defined by the Forestry Agency of Japanese government as the ratio of domestic wood supplied over the total wood consumed domestically (in log-equivalent volume), decreased from almost 90% in the beginning of the 1960s to less than 50% in 1969, and to as low as 30% in the 1970s (Figure 3).

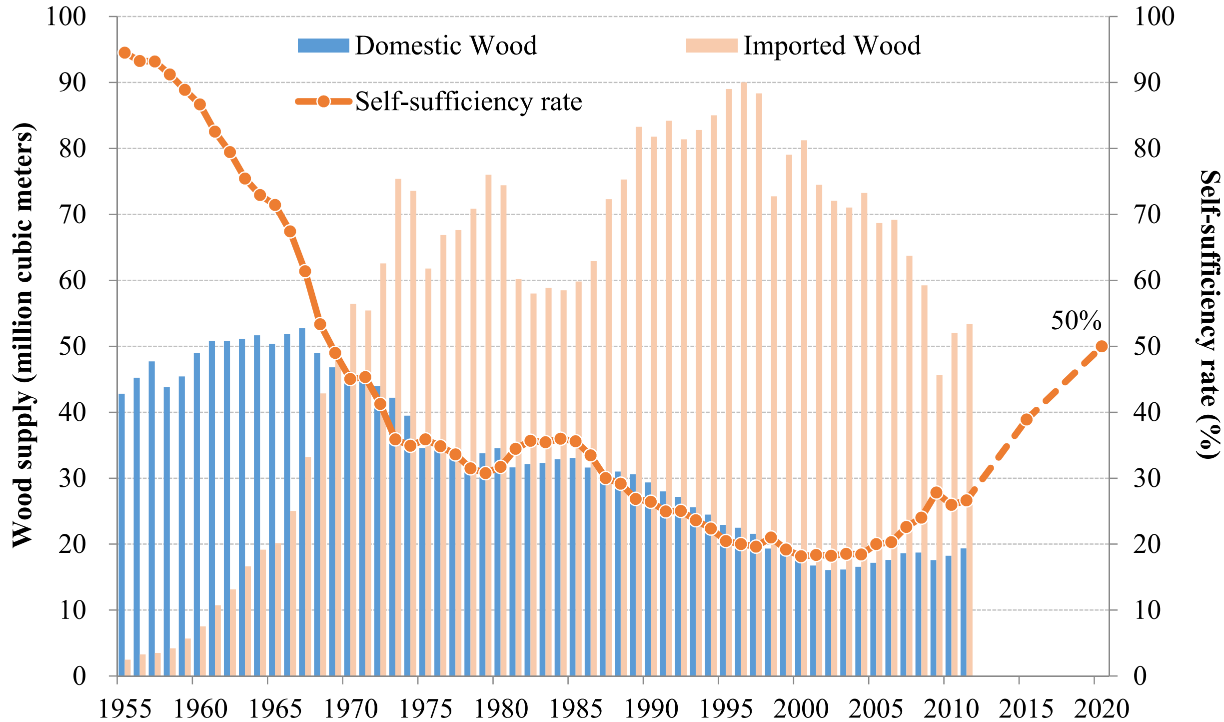

Figure 3. Wood supply by origin and self-sufficiency.

Source: Forestry Agency, 2012

Note: volume of imported wood includes both the volume of imported logs and the log-equivalent volume of imported products.

Although the decrease in wood imports after the oil shocks contributed to some resurgence in self-sufficiency in the early 1980s, accelerated wood imports during the bubble economy era as the yen strengthened after 1985 resulted in an ever-decreasing self-sufficiency rate. Only since 2003 has the supply of domestic wood started to increase. In contrast, wood imports began to show a downward trend in the early 2000's and the level dropped substantially in 2009 when Japan's economy was in a deep recession in response to the global financial crisis. These opposing trends caused the self-sufficiency rate to increase from its record-low of 18.2% in 2002 to a recent high of 26.6% in 2011, up 7.4% in just 9 years.

Domestic forest resources and timber supply

Since Japan's forest resources were depleted during WWII, there was much emphasis placed on reforestation programs in the postwar period so as to restore forests on deforested lands. The reforestation programs were then expanded to replace natural forest areas as wood prices began to increase in the 1960s. During the period from the 1950s through the early 1970s, the annual area reforested was between 300,000 and 400,000 hectares.

Since houses in Japan are traditionally built using wood, the reforestation activity was strongly characterized with its heavy preferences for softwood species. Among several native softwood species, *sugi* (Japanese [red] cedar, *Cryptomeria japonica*) was the most preferred as it grows straight and faster than other species, followed by *hinoki* (Japanese cypress, *Chamaecyparis obtusa*) which grows much slower than *sug*i but has greater strength. These two species accounted for 45% and 25% respectively of total domestic plantation forests in terms of area by 2007. Japanese red pine (*Pinus densiflora*) and Japanese larch (*Larix kaempferi*) were less preferred than *sugi* and *hinoki*, but still had substantial areas of plantation forests dedicated to them, resulting in a share of 9% and 10% of the current plantation area respectively.

The area of reforestation has declined substantially since the 1970s, dropping to around 30,000 hectares per year after 2000. This drastic change in the area of reforestation has resulted in an uneven age-class distribution of plantation forests (Figure 4). Approximately 70% of the area of plantation forests is between 31 and 60 years of age, whereas plantation forests younger than 30 years comprise only 22% of the total area. Given that plantation forests in Japan are usually harvested between 50 to 60 years of age, the current age class distribution suggests that a large volume of domestic timber will reach harvestable age over the next 20 years.

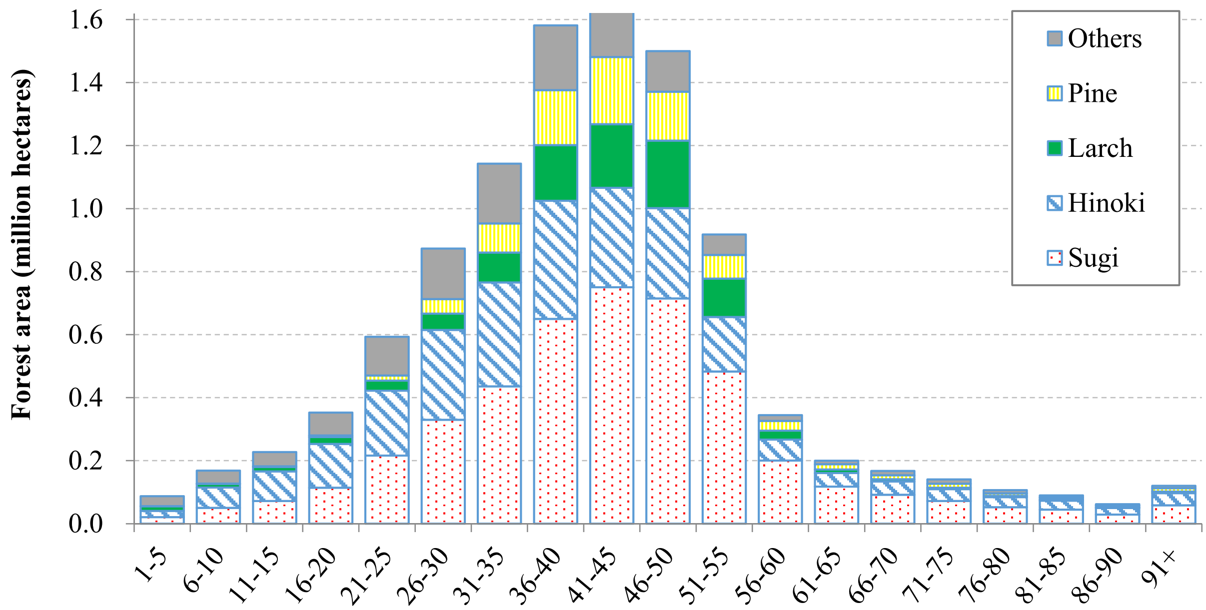

Figure 4. Area of plantation forest by tree species in Japan, as of 2007.
Source: Forestry Agency, 2007

Figure 5 shows the volume of domestic logs consumed to produce different wood products. The largest demand sector is the lumber industry, which has consistently comprised around 60% to 70% of the total demand for logs, followed by pulp and chips which used to comprise over 30% of total demand but has fallen to around 25% since the middle of the 1990s. While demand for domestic logs for plywood production had been historically low, due to its reliance on imported logs from Southeast Asian countries up to the 1980s and subsequently from Russia since the 1990s, it has been increasing rapidly since 2002 and now comprises 14% of total log demand.

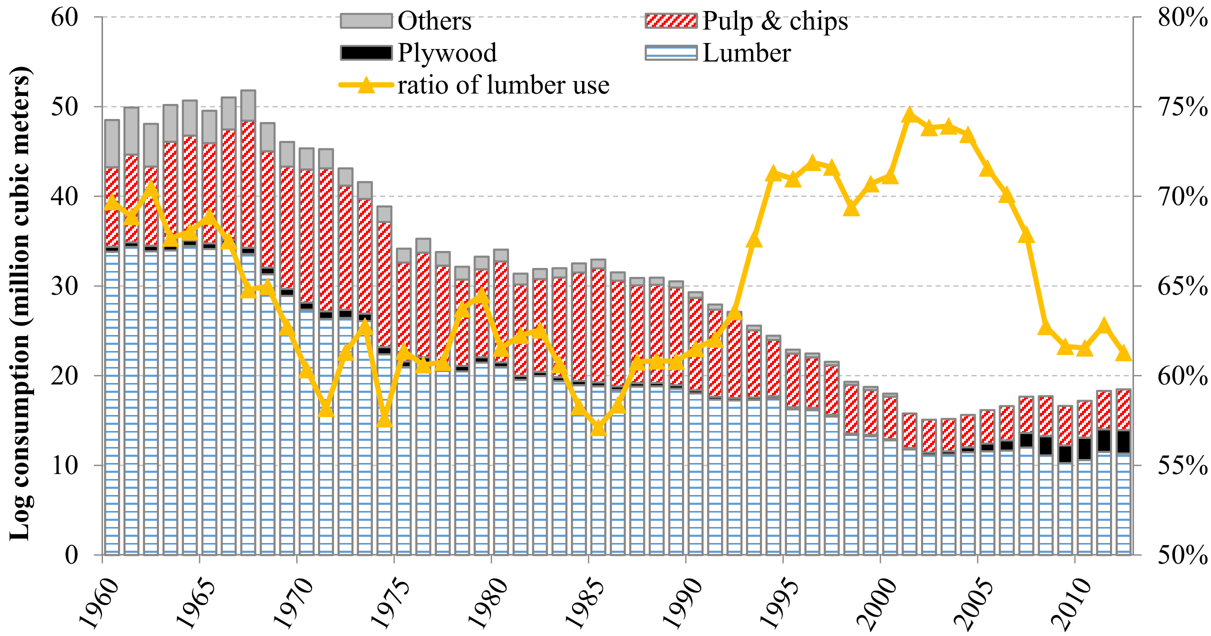

Figure 5. Log consumption volume in Japan, by application.
Source: Forestry Agency, 2012

Softwood species comprise more than 80% of the total domestic log harvest volume in recent years, whereas the ratio of hardwood logs has declined to less than 20% (around 2 million cubic meters) from its peak of over 40% (almost 20 million cubic meters) in the 1970s (Figure 6). Hardwood logs have been almost exclusively used for chip production, with over 90% going into chip mills in recent years, while a large percentage of softwood logs have been used for lumber production with a limited volume being used for plywood and chips.

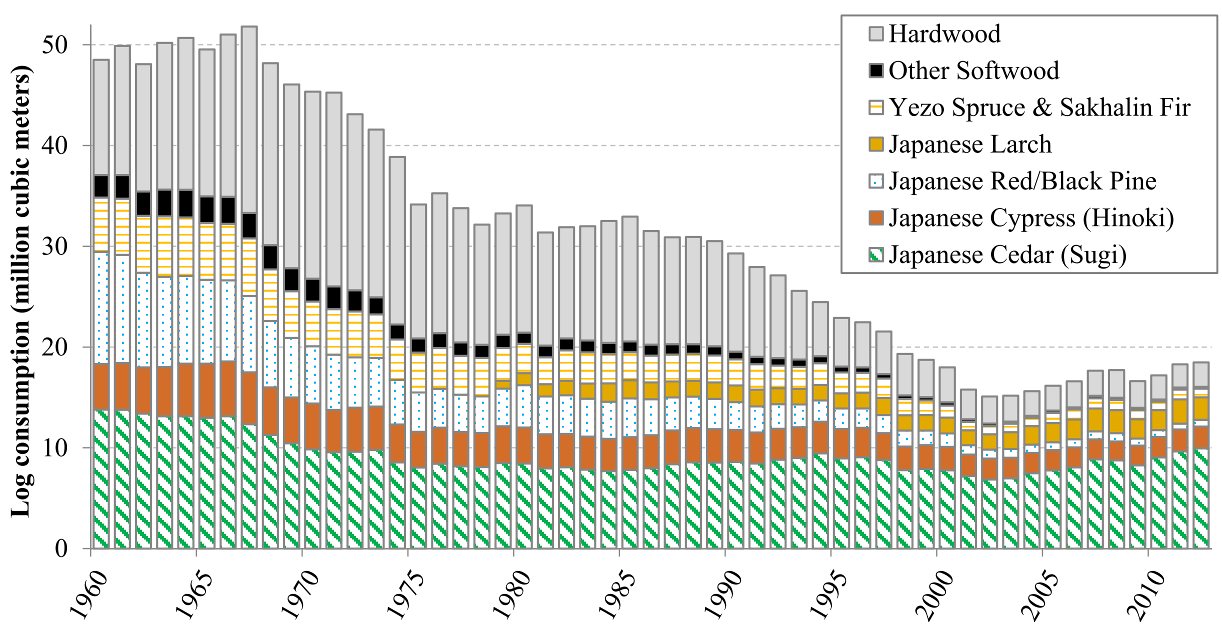

Figure 6. Log consumption volume in Japan, by species.
Source: MAFF, 2007-2012

The softwood log harvest volume declined from its 1960 peak of around 35 million cubic meters to a low of 12 million cubic meters in 2002. This is mainly because most softwood plantation forests were immature and unable to supply a large volume of wood as cheaply and efficiently as imported wood (MAFF, 2003). It is only since 2003 that the volume of softwood logs harvested has started to increase. Detailed by species, *sugi* has been the dominant species with the highest share of around 40% of domestic softwood supply, followed by *hinoki* and Japanese larch both between 10 to 15%. All of these species have been used largely to produce lumber, with increasing volumes of *sugi* and Japanese larch being used in the plywood industry in recent years. Although Japanese red pine was widely used in the Japanese traditional post and beam houses, especially for beams, its share has dropped dramatically as the pine wilt disease has caused a sharp decline in the pine resource since the 1970s.

It should be noted that almost all domestically produced logs have been consumed in Japan while the volume exported has been quite small. As of 2012, the volume of logs exported was 113,600 cubic meters, comprising only 0.8% of domestically produced logs.

Japan's wood imports

The volume of Japan's log imports has been in decline since the end of the 1970s, although Japan's total import value of wood products increased into the middle of the 1990s. This was primarily due to a shift from log imports to value-added products imports (MAFF, 2003).

The main suppliers of logs in recent years have been the U.S., Canada, and Russia, with market shares of 40%, 29% and 16%, respectively in 2012 (Figure 7). Log imports from the U.S. have decreased substantially since 1990, whereas those from Canada have been gradually increasing since 1998. While Russia was a major supplier of softwood logs into Japan, the volume of log imports from Russia plunged following the introduction of a 20% log export tax in 2007 and its increase to 25% in 2008. The share of Malaysian logs in Japan has also decreased substantially since the early 1990s as a result of a reduction of the domestic timber harvest in Malaysia (MAFF, 1991).

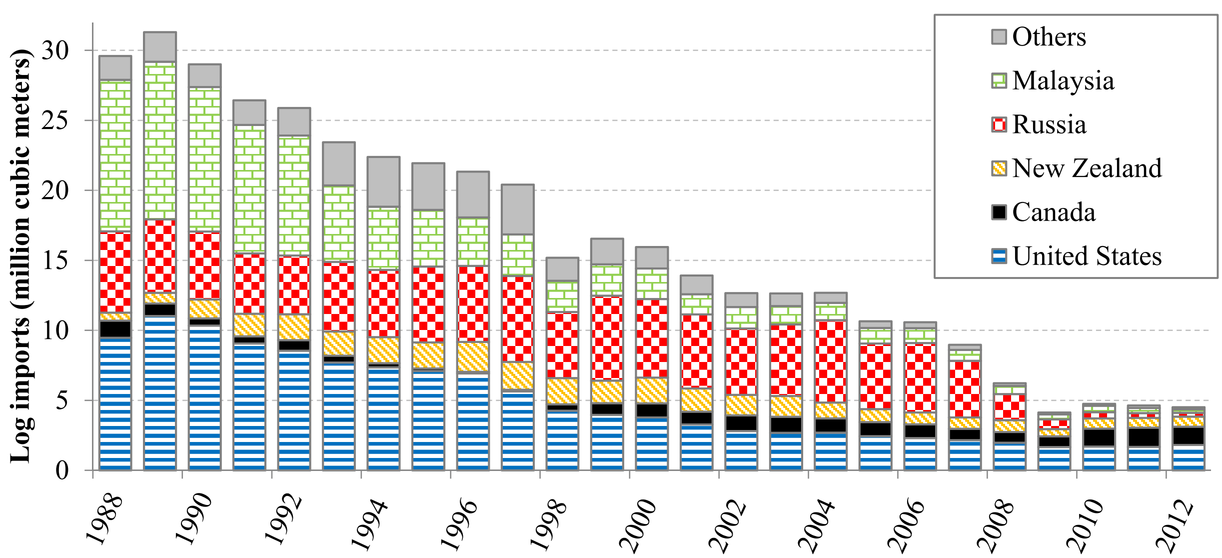

Figure 7. Japan's imports of logs (HS 4403), by source country.
Source: MOF, 2012

With respect to species distribution of log imports by Japan, Douglas-fir has long been the dominant species among softwood logs, comprising two thirds of total softwood log imports in 2012 (Figure 8). Douglas-fir logs have been primarily sourced from the U.S., although imports from Canada have been increasing since 1999. While pine and larch had been major imported log species into Japan in the 1990s and the early 2000s, imports of these species dropped substantially after the imposition of the high export tariff on logs by Russia, which had accounted for about half of pine log imports and almost all larch log imports. Similarly, imports of hemlock logs have greatly declined since the U.S. introduced restrictions on log exports from federal and state forests in the early 1990s (MAFF, 2001).

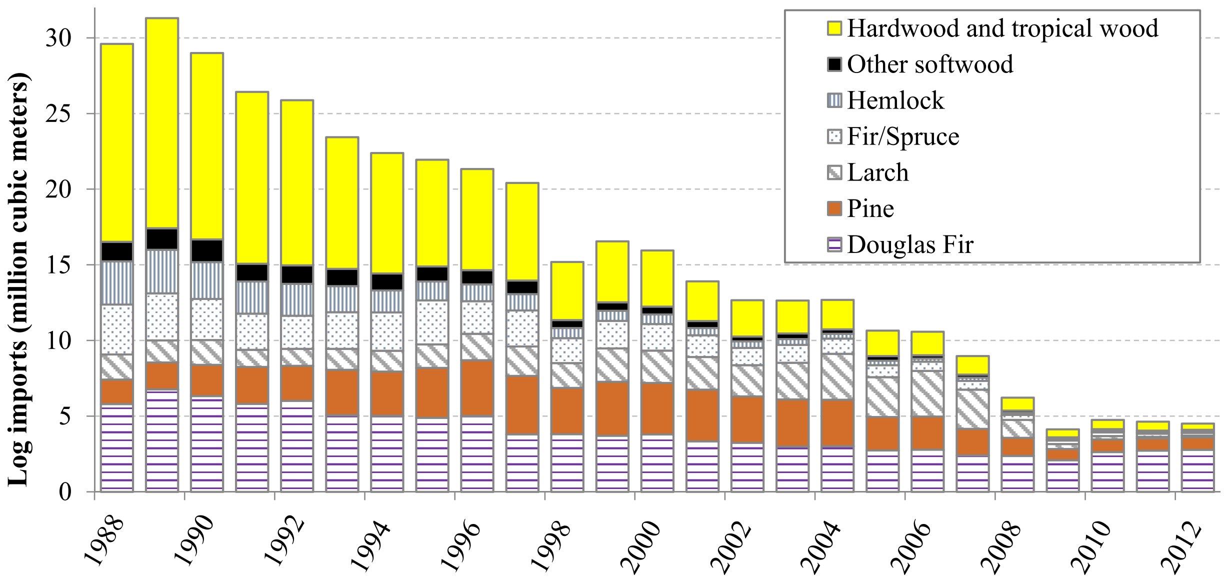

Figure 8. Japan's imports of logs (HS 4403), by species.
Source: MOF, 2012

Japan's lumber imports recorded their highest volume in 1997, and have been declining since then, although the extent of the decline is modest compared to that of log imports. Prior to the middle of the 1990s, Canada and the U.S. were the two major lumber suppliers to the Japanese market, representing around 70% of total lumber imports (Figure 9). However, since the mid-1990s, both countries, and especially the U.S., have lost substantial market share as Japanese imports of lumber from Europe, mainly from the Scandinavian countries, increased from 2% in 1993 to 37% in 2012 (Sasatani et al. 2005). Over the same period, the proportion of lumber imports from Canada and the U.S. dropped from 52% to 35% and 22% to 6%, respectively. Since 2004, Russia has become the third largest supplier of lumber to Japan, with a market share exceeding 10%.

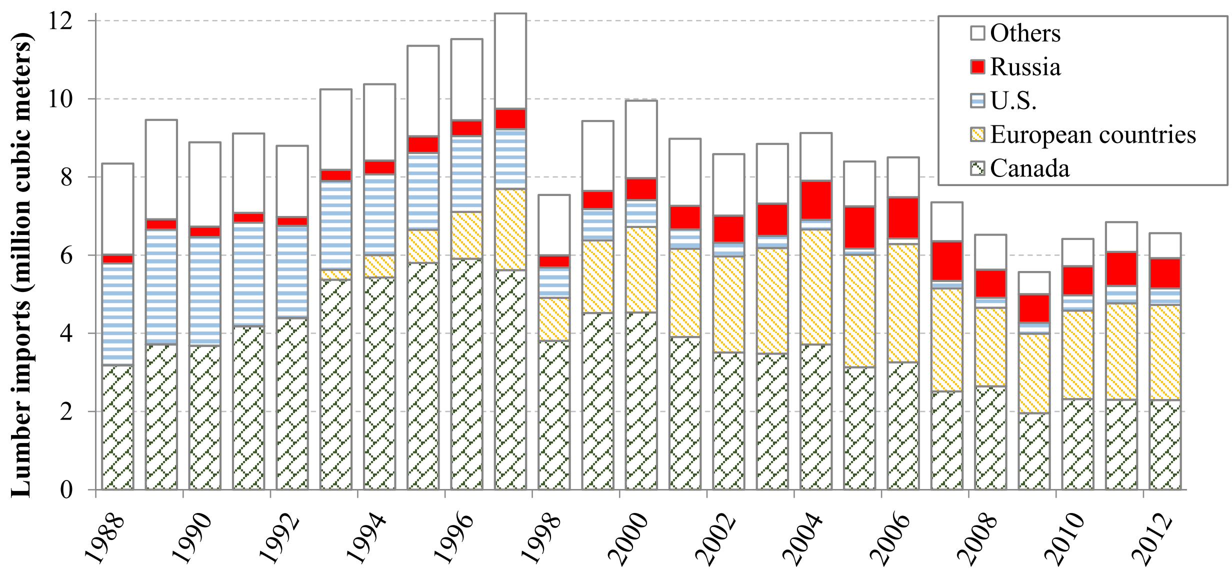

Figure 9. Japan's imports of lumber (HS 4407), by source country.
Source: MOF, 2012

The change in the mix of countries exporting lumber to Japan has affected the species composition of lumber imports. Douglas-fir and hemlock lumber, which have been sourced from the U.S. and Canada, were the major lumber species imported into Japan prior to 1997. Imports of these species began to decline in 1998 while the volume of fir, spruce, and pine lumber imported from Europe has increased substantially (Figure 10).

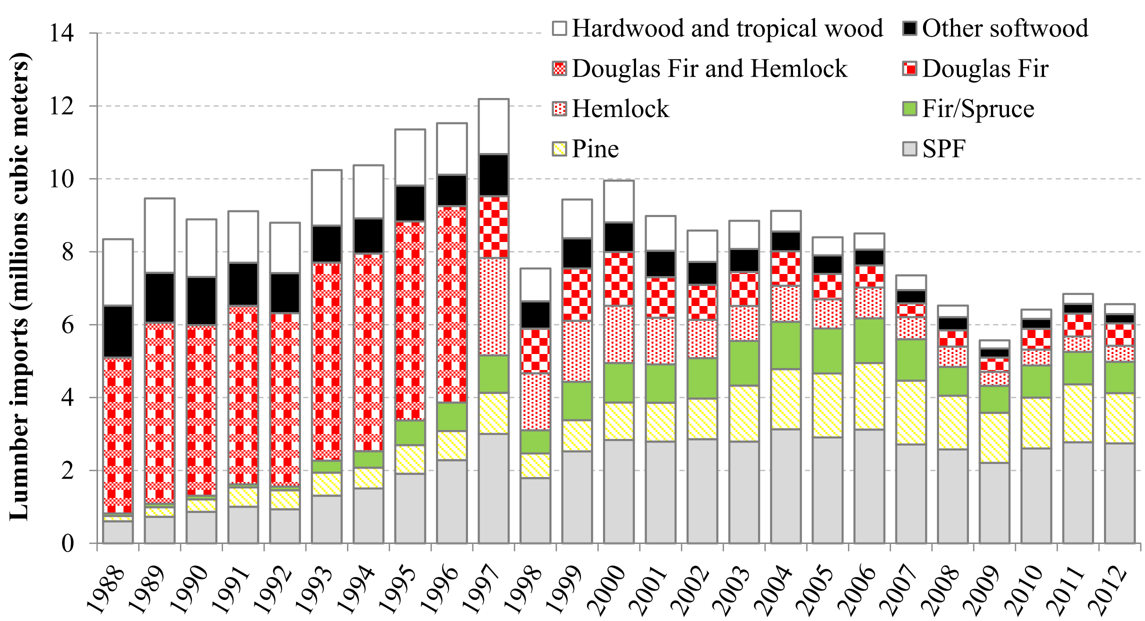

Figure 10. Japan's imports of lumber (HS 4407), by species.
Source: MOF, 2012

The competitive relationship between domestic wood and imported wood

Although the competitive relationship between domestic and imported wood at the species level is not directly observable, wood use in several end-use sectors gives us a hint as to how they compete in specific applications. Domestic and imported softwood logs are mainly processed by sawmills. The data on the volume of log consumption by Japanese sawmills indicates that there had been more imported logs used than domestic logs from 1970 through 2001. Since 2001, fewer imported logs and more domestic logs have been used in Japanese sawmills (Figure 11). The increasing usage of domestic logs by sawmills has partly been driven by a reduction in log imports resulting from policies that subsidize the domestic sawmill industry and favor the increased use of domestic species. Since 2009, the proportion of imported wood consumed by Japanese sawmills has been less than one third, indicating that many domestic sawmills have switched their raw materials inputs to domestic logs.

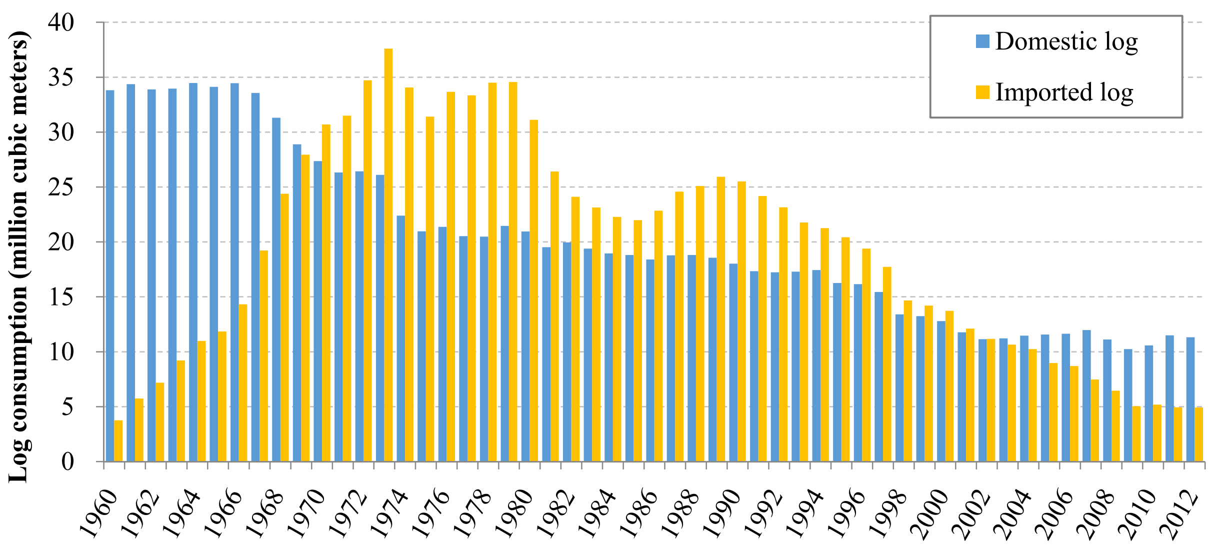

Figure 11. Volume of logs consumed by sawmills in Japan, by origin.
Source: MAFF, 2007-2012

For lumber, housing is estimated to be the largest demand sector in Japan, with approximately 80% of lumber produced going into housing construction. In 2005, MAFF estimated the proportion of domestic wood use in traditional wooden post and beam housing (Table 1). The estimation indicated that the ratio of domestic wood use in post and beam houses was 31%. By end-use application, the ratio of domestic wood use was especially low in beams and sill plates while more than half of posts were produced from domestic wood.

Table 1. Estimated ratio of domestic wood use in post and beam houses.

	Ratio		Total Wood Use
	Domestic Wood	Imported Wood	(million m^3: in log-equivalent volume)
Posts	54%	46%	3.7
Sills	28%	72%	1.6
Beams	5%	95%	6.5
Non-structural lumber	36%	64%	9.6
Fixtures & Trims	56%	44%	1.6
Total	31%	68%	23.0

Source: MAFF, 2007

Recent Japanese forestry policy

Except for the period of high economic growth when the government promoted wood imports to meet increasing wood demand, the Japanese government has focused exclusively on growing its domestic forestry and wood processing industries through a myriad of subsidy programs and regulatory frameworks including tax advantages and financial support (Eastin et al., 2002). Despite the enormous support by the governmental budget, domestic forestry had been plagued by inefficiency due to several structural problems, including a large proportion of immature plantations, the large number of small-scale forest owners, an undeveloped forest road network, high logging costs, increasing labor costs and the increasing age of forestry workers. The combination of these problems has increased the production costs for domestic wood, making it less competitive than imported wood (MAFF, 2010). Replaced by imported wood, domestic wood suffered continuous price declines, which lead to a further reduction in profitability within the forestry sector.

It is against this background that the Forestry Basic Act was amended to the Forest and Forestry Basic Act in 2001, which introduced the new concept of the multifunctional roles of forests. These functions include water conservation and carbon storage, as well as the wood production on which the original Act was focused. Under the concepts of promoting and sustaining the multifunctional roles of forests, further subsidies were provided by the government to promote thinning of plantation forests because forest owners were reluctant to conduct any forest management activities due to the continuously declining price of domestic wood. These subsidies caused the level of forest maintenance activities to remain relatively high even in disadvantaged areas where the profitability was expected to be negative (MAFF, 2010). In the meantime, MAFF started subsidizing the development of internationally competitive large-scale sawmills by promoting the use of local woods in regional sawmills through two subsidy programs: the "New Distribution System" and the "New Production System." Although these subsidy programs were partly successful, their effectiveness in increasing the demand for domestic wood was limited (MAFF, 2011a).

Since 2009 there have seen several significant changes and reforms in government policy regarding the forestry and wood processing industries in Japan. In the general election of August 2009, the Democratic Party of Japan (DPJ) won the majority of seats in the lower house of the Diet, leading to a change in government from the Liberal Democratic Party (LDP) which had been in power since 1955. One of the biggest issues the new DPJ government had to tackle was the economic recovery. Japan has been suffering from a sluggish economy over the past two decades as well as a high unemployment rate (over 5%) in the aftermath of the 2008 global financial crisis. In October 2009, the DPJ government, which had received wide support from labor unions in the election, developed the "Urgent Employment Measures" policy in which much emphasis was placed on creating jobs in "the green industry". Under these Measures, forestry and wood manufacturing were considered to be priority sectors.

In response to the announcement of the Measures, MAFF developed the "Forest and Forestry Revitalization Plan" in December 2009 as a comprehensive strategy to revitalize the domestic forestry and wood processing industries over a ten year period. The Revitalization Plan was designed "to convert Japan's society from a "concrete society" into a "wood society" which would more fully utilize the forest resource to contribute to employment and a better environment," and set the goal of achieving a 50% self-sufficiency rate in timber supply in ten years. It appears that the Revitalization Plan was based on the "Forest and Rural Areas Revitalization Plan" which the DPJ had developed two years prior to the 2009 election based on the fact that the initial DPJ plan also set a goal of increasing self-sufficiency to 50% in 10 years and shared several similar measures to achieve that goal.

The major components of the current Revitalization Plan include: 1) reforming the forest planning system, 2) developing a system to ensure sustainable forest management, 3) accelerating the development

of the forest road networks, 4) developing and training forest management contractors, 5) developing an efficient processing/distribution system for domestic wood products, 6) expanding the domestic demand for wood products and biomass, and 7) developing and training forestry technicians and coordinators.
In March 2010, MAFF set up several study groups comprised of people from academia, industry, and the government in order to better implement each component of the Revitalization Plan. After discussing the detailed measures for eight months, the study groups prepared a final report on the direction of reform in November 2010, pointing out that "past policies on forest and forestry have focused primarily on establishment of forest resources, and (the government has) provided subsidies on wide range of forest management activities, such as thinning, without having concrete visions for sustainable forest management and frameworks necessary for the implementation of the visions," and, in order to achieve the self-sufficiency rate of 50% in 10 years, the "following measures should be implemented: 1) establishing a proper system to ensure proper forest management, 2) establishing low-cost operation systems nationwide, 3) developing forest management contractors and forestry technicians 4) streamlining processing and distribution systems of domestic wood and expanding the use of domestic wood" (MAFF, 2010).

In response to the final report, MAFF revised the Forest Act in April 2011 in order to introduce a new Forest Management Plan system to promote coordination and consolidation of forestry practices among groups of small forest owners, introduced a new subsidy program called the "Forest Management and Environmental Conservation Direct Support System" by which costs of forest management, such as thinning and forest road construction are substantially subsidized. MAFF also developed the new "Forest and Forestry Basic Plan" in July 2011 so that the domestic wood supply would comprise 50% of the total wood demand in 2020 (Table 2). In addition, a number of new government subsidy programs have been implemented in the wood processing sector since 2011 in accordance with the Revitalization Plan.

Table 2. Goal of domestic wood supply and outlook for total wood demand.

(Unit: million cubic meters)	Domestic Wood Supply			Total Wood Demand		
	2009	**2015**	**2020**	**2009**	**2015**	**2020**
Lumber use	11	14	19	26	27	30
Pulp and Chip use	5	9	15	29	36	37
Plywood use	2	4	5	8	8	9
Others	1	1	1	2	2	2
Total	**18**	**28**	**39**	**65**	**72**	**78**
Self-sufficiency	**-**			**28%**	**39%**	**50%**

Source: MAFF, 2011b

It should be noted that, based on the minutes of the study groups issued by MAFF (2010-2011), the discussion of the study groups focused largely on the question of how to increase the supply of domestic logs and increase the demand for them in domestic mills, and paid little attention to the competitive relationship between domestic and imported logs. It seemed throughout the whole discussion that domestic and imported logs were presumed to be perfect substitutes and that any increase in the domestic wood supply would inevitably replace the demand for imported wood. In spite of the substantial potential impacts on Japan's wood imports as well as on the supplier countries that the Revitalization Plan might have, a competitive analysis of this issue was not officially conducted. In addition, while the potential impacts of the policy on trade activities could be analyzed using trade models, the assumption behind most models that domestic and imported wood are perfect substitutes has not been examined at all.

Hypothesis and Literature Review

The competitive relationship between domestic and imported wood was tested using the idea of market integration. Markets are said to be integrated if, at equilibrium, the law of one price (LOP) holds and no arbitrage opportunity exists as a necessary condition for price efficiency. The LOP is a test for market integration and is assumed to hold in several trade models for wood products (Nagubadi et al., 2001). If the LOP is upheld then trade models that assume price equilibrium exists among homogenous products can be used to study the effects that the Revitalization Plan would have on domestic and other nation's wood markets in terms of changes in the volume of wood traded, whereas if the LOP does not hold to be true, then the use of these trade models would not be appropriate and any results yielded by those trade models may not be correct.

According to Baulch (1997), markets are integrated if prices in different markets move together and their price differential equals the transfer costs, including transportation and transaction costs. If there is an equilibrium relationship between two markets, the prices in these markets cannot diverge by more than a small amount in the long-run (Engle and Granger, 1987). In order to find this price behavior, the assumption that product prices in different markets do not behave independently has to be tested. The degree and extent of market integration has several implications for markets (Thorsen, 1998). It may give important information concerning the competitive strengths and weaknesses of individual markets. Strong integration may imply that any policy decision made by significant agents, such as industry or government, on any market will directly affect all the markets involved. Conversely, weak integration or lack of integration among markets may indicate that political measure targeted to influence a market would not be transmitted to other markets.

Study hypothesis

In this study, it is hypothesized that the domestic and imported wood markets are integrated in Japan. If both woods compete in a single Japanese market, then the law of one price, the necessary condition for substitution between imported and domestic wood to occur, must hold.

In the following section, a cointegration model was employed to test the integration of markets. After discussing the results and the implications of the tests, an analysis of Japan's forestry policy measures and their effect on the Japanese wood market was made.

A number of previous studies have examined the market integration of forest products in North America and Europe. The concept of market integration was already discussed in the previous section. Many studies have used cointegration analysis to test for market integration and whether the LOP holds in a variety of wood products markets. The following discussion provides a review of the economic and forest products literature in three areas.

U.S. and Canada

In the U.S. and Canada, cointegration analysis has been used to examine markets for softwood lumber (Jung and Doroodian, 1994; Murray and Wear, 1998; Nanang, 2000; Yin and Baek, 2005), timber (Nagubadi et al., 2001; Yin et al., 2002), log and lumber (Stevens and Brook, 2003; Yin and Xu, 2003), stumpage (Prestemon and Holmes 2000, Daniel 2011), and pulp and paper (Buongiorno and Uusivuori, 1992; Alavalapati et al., 1997). These studies generally examined the extent of integration in regional wood product markets in the U.S. and Canada and discussed the appropriateness of assuming spatial equilibrium in modeling markets and the international trade of wood products. The results of these studies have been mixed; with some studies confirming that the LOP held nationwide and concluding that there was a single national market for the product, while other studies found that regional markets were not integrated but rather that there existed several segmented markets within the country.

Some other studies have focused on the existence of the LOP with respect to the softwood lumber trade dispute between the U.S. and Canada. Shahi et al. (2006) found that the LOP did not exist within the U.S. and Canadian regional SPF markets but that some of the regional markets for homogeneous products were cointegrated. On the other hand, Baek (2006) found that the North American softwood lumber markets were integrated, with the U.S. price significantly affecting Canadian lumber prices. Shook et al. (2009) also confirmed a cointegrating relationship between the prices of North American softwood lumber species, but failed to conclude that those species were perfect substitutes based on their finding that the cointegration among the price series was likely to be caused by common demand-side factors, such as construction activity.

Europe

Cointegration analysis has also been extensively used to study the market integration of wood products in European countries. Studies on market integration in Europe are well summarized by Toppinen and Kuuluvainen (2010). As they pointed out, there have been a number of studies, especially in Scandinavian countries, on the integration of regional log markets (e.g. Rii, 1996; Thorsen, 1998; Toppinen and Toivoinen, 1998; Toivonen et al., 2002; Mutanen and Toppinen, 2007). Their studies generally indicated that the prices of log markets were cointegrated and that markets in northern Europe roughly form a single market. Cointegration tests have also been used to analyze the markets for other wood products, such as imported softwood lumber (Hanninen, 1998; Mutanen, 2006) and newsprint (Hanninen et al., 1997), as well as the inter-market relationships between domestic, imported, and exported products of the same commodity (Nyrud, 2002; Stordal and Nyrud, 2003). The results of these studies were mixed and dependent on the region studied: for example, while Mutanen (2006) found that the German sawnwood import market was well integrated, Hanninen (1998) concluded that violation of the LOP among softwood lumber imported into the United Kingdom suggested imperfect competition models should be used in explaining and forecasting UK imports.

Japan

To date, little work has been done on the integration of wood product markets in Japan. Yukutake et al. (2008) studied the existence of the law of one price for logs and lumber of several tree species including both domestic and imported wood in the Japanese market by performing cointegration tests on monthly data from 1974 to 2001. They found through their analysis that some of the price series were cointegrated and that markets for *sugi* and hemlock could be regarded as being integrated, whereas *hinoki* was not connected to any of the other markets.

Methodology

Theoretical framework

Following the methods used in other studies, market integration will be tested using cointegration analysis in this study. Several methods have been established for conducting the cointegration test. The most widely used techniques include the Engle-Granger residual-based test (Engle and Granger, 1987) and the Johansen's maximum-likelihood-based test (Johansen, 1995). According to the cointegration theory, a (N×1) vector time series, $\boldsymbol{x_t}$, is said to be cointegrated if each of the elements of $\boldsymbol{x_t}$ is non-stationary with a unit root, or $I(1)$, individually, but that some linear combination of the series, $\boldsymbol{a'x_t}$, is stationary, or $I(0)$, for some nonzero (N×1) vector $\boldsymbol{a}$ (Engle and Granger, 1987). Consequently a test of the null hypothesis that $z_t = \boldsymbol{a'x_t}$ is (I) is equivalent to a test of null hypothesis that $\boldsymbol{x_t}$ is not cointegrated for a specific value $\boldsymbol{a}$**.** If the null hypothesis is rejected, it is concluded that z_t is stationary, or that $\boldsymbol{x_t}$, is cointegrated.

In the context of this study, cointegration implies that while the price series of various softwood sawlog[1] and lumber species, $\boldsymbol{x_t}$, may behave like random walks, over the long run they tend to drift in similar fashion, causing a linear combination of them, $\boldsymbol{a'x_t}$, to reduce to a stationary process.

In the following two sections, methods to examine the cointegrating relationship between price series are described. Firstly, the time-series properties of the data are scrutinized by using unit root tests in order to find the non-stationarity in each price series. Once non-stationarity of price series is confirmed by the unit root test, then the Johansen's multivariate cointegration test is implemented in order to find cointegrating relationships among several non-stationary price series.

Testing for stationarity in the individual price series

The cointegration method presupposes that the series to be tested are non-stationary unit root processes: a price series is stationary when the mean, variance, and covariance of the series are constant over time and non-stationary when they are not. Hence a unit root test must be conducted prior to a cointegration estimation to determine whether each price series is stationary or non-stationary. If a price series is stationary, it should be excluded from the cointegration estimation. Many unit root tests have been suggested to test stationarity properties. In this study, the Dickey-Fuller unit test is employed (Dickey and Fuller, 1979). Consider the first-order autoregressive process, or AR(1):

$$p_t = \mu + \rho p_{t-1} + \varepsilon_t$$

where μ and ρ are parameters; p_{t-1} is the first lag of variable p_t, and ε_t is the residual. p_t is a stationary series if $|\rho| < 1$; a shock to the series would eventually result in convergence back to a steady state. When $\rho = 1$, p_t is considered to be a random walk with drift μ; any shock to the series will have permanent effects and the variance will increase over time. The null hypothesis H_0: $\rho = 1$ is tested against the one-sided alternative Ha: $\rho < 1$. The test is carried out by estimating an equation with p_{t-1} subtracted from both sides of the equation:

$$p_t - p_{t-1} = \mu + (\rho - 1)p_{t-1} + \varepsilon_t$$

$$\Delta p_t = \mu + \gamma p_{t-1} + \varepsilon_t$$

where $\gamma = \rho - 1$. The null and alternative hypotheses may be written as H_0: $\gamma = 0$ and Ha: $|\gamma| < 0$. The test statistic is the ratio of γ to its standard error. The test is conducted under the null hypothesis of a unit root. If the calculated ratio is significantly different from zero, then the hull hypothesis is rejected. The critical values calculated by Dickey and Fuller are used to determine the significance of γ. There are two important considerations when testing for a unit root. One factor is whether to include a constant term, a

[1] The term sawlog refersto logs that are used for lumber production

constant and a time trend, or neither in the test equation. Including an irrelevant regressor reduces the power of the test to reject the null hypothesis of a unit root. Another aspect is the choice of lag length to eliminate the possible correlation in the error terms. In order to consider these two aspects, unit root tests are conducted using the augmented Dickey-Fuller (ADF) unit root test, which allows for adding correlation at higher order.

The ADF test is conducted by adding the lagged difference terms of the dependent variable to the right-hand side of the test regression:

$$\Delta p_t = \mu + \gamma p_{t-1} + \sum_{i=1}^{m} \delta_i \, \Delta p_{t-i} + \Phi D_t + \varepsilon_t$$

where μ is a constant, Φ the coefficient of time trend D_t, m the number of lags required to remove correlation in the error terms (lag order), Δp_{t-i} the first-difference operator, and ε_t a stationary error term. The null hypothesis is the same as that for the DF test and the limit distributions of the estimated parameters are similar to those for the DF test. The number of lags to include in the equation is determined using the Akaike Information Criterion (AIC) with a maximum lag length of 12 months.

Johansen's multivariate cointegration test

Once non-stationarity of the series has been confirmed using the ADF test, Johansen's multivariate cointegration test is implemented in order to test the market integration. Although the Engle-Granger (1987) cointegration test has been used for cointegration analysis in many early works, it has been criticized on the grounds that it is a two-step process, and that the cointegration is confined to pairwise comparisons which require that one of the two variables be designated as exogenous (Nagubadi et al., 2001). Also, the use of the Engle-Granger cointegration method for testing the LOP using pairwise comparisons may suffer from simultaneous equation bias if more than two price series are modeled, since the prices are determined simultaneously under the assumption of the LOP. Moreover, while the number of cointegration vectors may be more than one, it is not possible to determine more than one vector using the Engle-Granger method (Nanang, 2000). In contrast to the Engle-Granger test, Johansen's maximum likelihood procedure for cointegration tests identifies cointegrating relationships in a multivariate system. This procedure does not require that one of the variables be designated as exogenous in a pairwise testing. In Johansen's methodology for the multivariate cointegration test, the basic statistical model is an unrestricted p-dimensional vector autoregressive (VAR) model of lag order k, as given:

$$y_t = A_1 y_{t-1} + \cdots + A_k y_{t-k} + \mu + \Phi d_t + \varepsilon_t$$

Where y_t is a $(p \times 1)$ vector that denotes the t^{th} observation on a set of p variables in levels, μ is a $(p \times 1)$ vector of intercept terms, $\Pi_1, \ldots, \Pi_k$ are $(p \times p)$ matrices of parameters, d_t represents a matrix of non-stochastic variables like seasonal dummies, Φ is a $(p \times 1)$ vector of coefficients for the non-stochastic variables and ε_t is a $(p \times 1)$vector of normally, independently and identically distributed (NIID) disturbance terms with zero mean and variance-covariance matrix, $\varepsilon_t \varepsilon_t' = \Omega$. The k-th order VAR in levels in the above equation can be reparametarized and reformulated (Johansen 1995) as an error correction form as follows:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta y_{t-i} + \Phi d_t + \varepsilon_t$$

where $\Pi = \sum_{i=1}^{k} \mathrm{A}_i - I$, $\Gamma_i = -\sum_{j=i+1}^{k} \mathrm{A}_j$, Δ is the first difference operator, Δy_t is a $(p \times 1)$ vector of variables integrated of zero order, i.e., $I(0)$, in the system, Π and Γ_i are coefficient matrices, and the other

symbols are the same as defined in the previous equation. The Γ_i describes the short run dynamics of the system and Π is the matrix of the long-run coefficients. The rank of the long-run matrix, $\Pi = \alpha\beta'$, determines the number of cointegrating vectors in the system. The information about the long-run dynamics of the system is embedded in the matrix β, and the short-run effects of disequilibria are measured by the matrix α. The columns of the matrix β are the cointegration vectors representing the stationary linear combination of variables y_t. The respective columns of matrix α give the weights with which the error correction terms enter each equation, indicating the speed of adjustment to equilibrium. The lag lengths (k) in VAR models were determined by the Schwarz information criterion (SIC).
The likelihood ratio test devised by Johansen (1988) measures the number of cointegration vectors in the data. This test, also called a trace test, is used to test the rank of the cointegrating matrix, and is given by:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i)$$

where T is the number of observations, $\hat{\lambda}_i$ are the estimated eigenvalues obtained from the estimated Π matrix, and r is the rank indicating the number of cointegration vectors. The rank, r, of matrix Π determines the number of cointegration vectors in the system of variables. The number of cointegration vectors can be thought of as representing the restrictions that an economic system imposes on the movement of the variables in the VAR model in the long-run (Dickey et al., 1991).

If there are p variables in the system, full market integration requires a rank of p-1 (Goodwin and Grennes, 1994). If the rank matrix Π is less than p-1, the hypothesis of full market integration is rejected, In this case, the degree of market integration is said to be lower and the law of one price does not hold in all p variables simultaneously.

Data Description and Preliminary Analysis

The data for the study consisted of the monthly prices of sawlogs and lumber in Japan for domestic and imported wood over the period of January1985 to December 2012. The price information for these items was obtained from the Wood Supply and Demand Report for 1985-2010 and Timber Price Survey for 2011-2012, both issued by MAFF[2], except for the prices for European whitewood glue-lam which were obtained from the *Nikkan Mokuzai Shinbun* (Japan Forest Products Journal)[3].

Domestic wood was defined here as being grown and harvested in Japan, while imported wood was grown and harvested overseas and imported into Japan as sawlogs or lumber. Lumber domestically processed from imported sawlogs was also categorized as imported wood. Since single price data representing each item, such as the aggregate domestic lumber price or the aggregate imported sawlog price, were not available in MAFF's statistics, price series at the tree species level by origin were used for the following analysis. Items included in the analysis were identified on the basis of the domestic consumption level over the study period, but the availability of data in MAFF's statistical database restricted the item selection. For sawlog price series, *sugi* (Japanese cedar), *hinoki* (Japanese cypress), and Japanese larch were chosen as the domestic wood species, while Douglas-fir, hemlock (both from North America), Russian larch and Russian Yezo spruce (both from Russia) were selected as imported wood species.

For the lumber price series, *sugi* and *hinoki* were chosen as the domestic wood species, and Douglas-fir, hemlock, and Russian Yezo spruce were selected as the imported wood species. In addition to these items, the price series for kiln-dried (KD) lumber of *sugi* and *hinoki* as well as European whitewood glulam were included in the lumber price analysis for the time period January 1998 to December 2012.

The properties for each item are summarized in Table 3. It should be noted that the price series of logs and lumber of Douglas-fir and hemlock are categorized as originating from North America, meaning that they are from either the U.S. or Canada, and there is no distinction about which country those wood products come from in MAFF's statistics database. All price series include the consumption tax and are reported in Japanese yen per cubic meter[4]. The following analysis was carried out using the price series in logarithm transformation.

[2] In MAFF's statistics, sawlog price is the delivered price at sawmills and the lumber price is the wholesale price. Prices for sawlogs were originally collected from sawmills in several selected prefectures in which about 80% of the nation's total consumption of logs occurs. Prices of lumber were originally collected from privately and cooperatively managed wood markets and wood wholesalers in ten prefectures which have a large distribution volume of lumber within the prefectures. Both price series are aggregated at the prefectural level by taking the simple average of the prices in the prefecture, and then again aggregated to represent the price at the national level by taking the weighted average of prefectural prices based on the prefecture's share of wood for each wood product in a particular base year. In the case of the Wood Supply and Demand Report between 2006 and 2010, for example, 2005 was chosen as the base year.

[3] Unlike other price series in the MAFF statistics, prices for whitewood glulam from the *Nikkan Mokuzai Shinbun* were not aggregated spatially but represent a single market in the Tokyo area.

[4] Price series for European whitewood was originally recorded per piece. For convenience, they were converted to price per cubic meter by multiplying by a coefficient of 30.234.

Table 3. Data description for sawlog and lumber price series.

Sawlog

Origin and Species	Grade	Dimension (Height× Width × Length)	Abbr.	Sampling period
North America				
Douglas-fir	#3	30- cm × 6.0- m	S_DF	1985.1 – 2012.12
Hemlock	#3	30- cm × 6.0- m	S_HEM	1985.1 – 2012.12
Domestic				
Japanese cypress	Mix	14-22 cm × 3.65-4.0 m	S_JC	1985.1 – 2012.12
Japanese larch	Mix	14-28 cm × 3.65-4.0 m	S_JL	1985.1 – 2012.12
Japanese red cedar	Mix	14-22 cm × 3.65-4.0 m	S_JRC	1985.1 – 2012.12
Russia				
Russian larch*	Mix / for plywood	20- cm × 4.0- m / 20-28 cm × 3.8- m	S_RL	1985.1 – 2012.12
Russian Yezo spruce	Mix	20-28 cm × 3.8- m	S_RYS	1985.1 – 2012.12

Lumber

Origin and Species	Grade	Dimension (Height× Width × Length)	Abbr.	Sample period
North America				
Douglas-fir	2nd	Hirakaku, 10.5-12 cm × 24.0 cm × 3.65-4.0 m	L_DF	1985.1 – 2012.12
Hemlock*	2nd	Square, 10.5 cm × 10.5 cm × 3.0 m	L_HEM	1985.1 – 2012.12
Domestic				
Japanese cypress	2nd	Square, 10.5 cm × 10.5 cm × 3.0 m	L_JC	1985.1 – 2012.12
Japanese cypress (KD)	2nd	Square, 10.5 cm × 10.5 cm × 3.0 m	L_JCKD	1998.1 – 2012.12
Japanese red cedar	2nd	Square, 10.5 cm × 10.5 cm × 3.0 m	L_JRC	1985.1 – 2012.12
Japanese red cedar (KD)	2nd	Square, 10.5 cm × 10.5 cm × 3.0 m	L_JRCKD	1998.1 – 2012.12
Russia				
Russian Yezo spruce	1st	Board, 1.3-1.5 cm × 15.0 cm × 3.65-4.0 m	L_RYS	1985.1 – 2012.12
Europe				
Whitewood glulam	1st	Square, 10.5 cm × 10.5 cm × 3.0 m	L_WW	1998.1 – 2012.12

Source: MAFF, 2007-2011

*Note that, because of the data availability, price series of Russian larch sawlog is a combination of price data of Russian larch log for lumber production from 1985 to 2001 and that of Russian larch log for plywood production after 2002. Price series of hemlock lumber is also a combination of price series of hemlock square lumber from 1985 to 2006 and that of treated hemlock square lumber (the same dimension) multiplied by 0.87 (for adjustment) after 2007.

Issues on structural change in the data

Structural change is an important issue in time-series analysis and affects all the inferential procedures associated with unit roots and cointegration tests (Maddala and Kim, 1998). If there is a break in the deterministic trend, then unit root tests could lead to a false conclusion that there is a unit root, when in fact there is not (Perron, 1989). Thus, the existence of structural change should be considered in testing stationarity as well as the cointegration of time series data.

In this study, the effect of a potential structural change on the conclusion on market integration was examined by dividing the price data at a certain time point. Potential structural changes were determined by looking at the shape of price charts and examining corresponding historical events. For sawlog price series, North American sawlogs (Douglas-fir and hemlock) were suspected to have experienced a structural change around 1992, which corresponds with the federal timber harvest reductions in the Pacific Northwest in the U.S. This structural change was supported by research by Baek (2006) in which he found that the price series of U.S. and Canadian lumber experienced structural shifts in 1992 due to the restriction on federal timber harvests.

For lumber price series, almost all price series seemed to have experienced a structural change between 1997 and 1998, which could correspond with the huge drop in domestic housing starts in 1997 in Japan against the backdrop of the economic downturn caused by the Asian financial crisis as well as the introduction of the higher consumption tax rate (from 3% to 5%) in Japan. This period is also the time when European whitewood imports began to increase, replacing North American lumber in the Japanese wood market.

Given these historical facts and derived assumptions, price data for both sawlogs and lumber were divided into two periods based on the breakpoint estimated above. Since the interest in the competitive relationship between domestic and imported wood in this study applies to the more recent period, price series for the period after 1992 for sawlogs and after 1998 for lumber, were analyzed, in addition to the data for the entire period of 1985 to 2012 for both sawlog and lumber[5].

Price series for sawlogs and lumber by timber species for the period of analysis are presented in Figure 12 and 13 respectively. These figures illustrate relatively different patterns of movement between the price series of domestic wood species and those of imported wood species: price of domestic wood species, especially Japanese cypress, have declined over time, whereas imported wood species tend to fluctuate within a certain price range. Nevertheless, several simultaneous responses among price series, such as the one in 1987 and in 1996, indicate that linkages among price series may exist.

[5] Although there was a huge change in Japan's import of Russian wood after 2007, when Russia introduced a high export tax on roundwood, the potential break caused by this event was not considered in this study. This is because the sample size for the period of analysis, 2007 through 2012, was considered to be too small to be tested statistically.

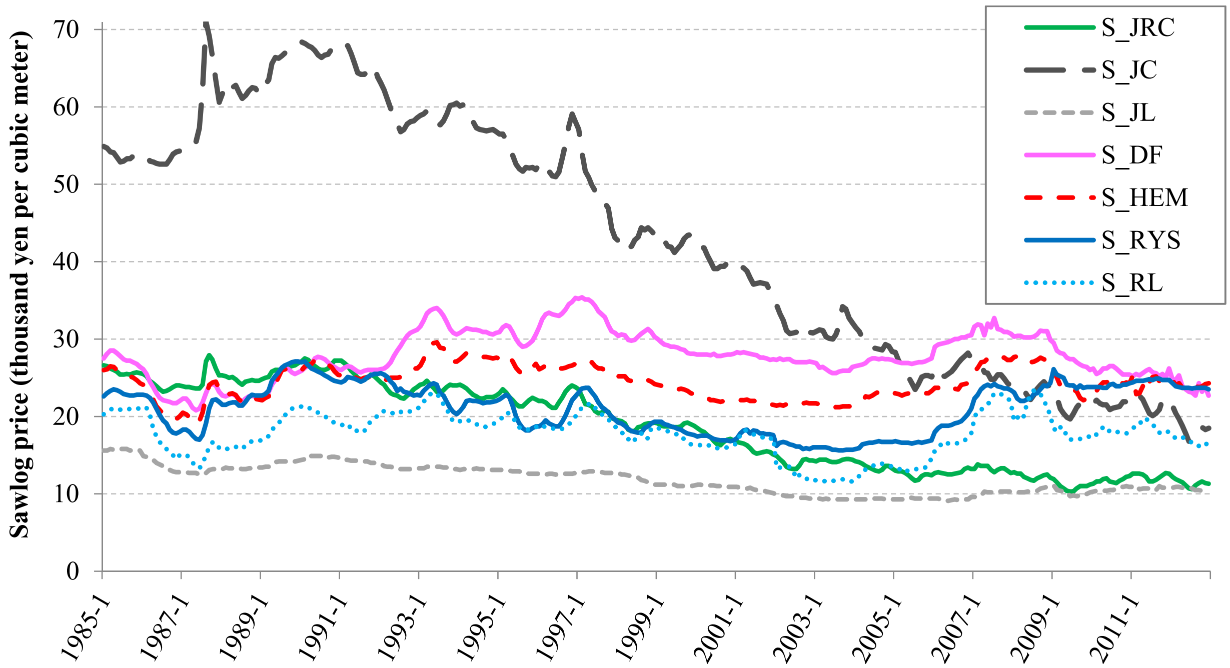

Figure 12. Sawlog prices in the Japanese market, Jan. 1985 through Dec. 2012.
Source: MAFF, 1985-2012. (Price series abbreviations for sawlogs are explained in Table 3).

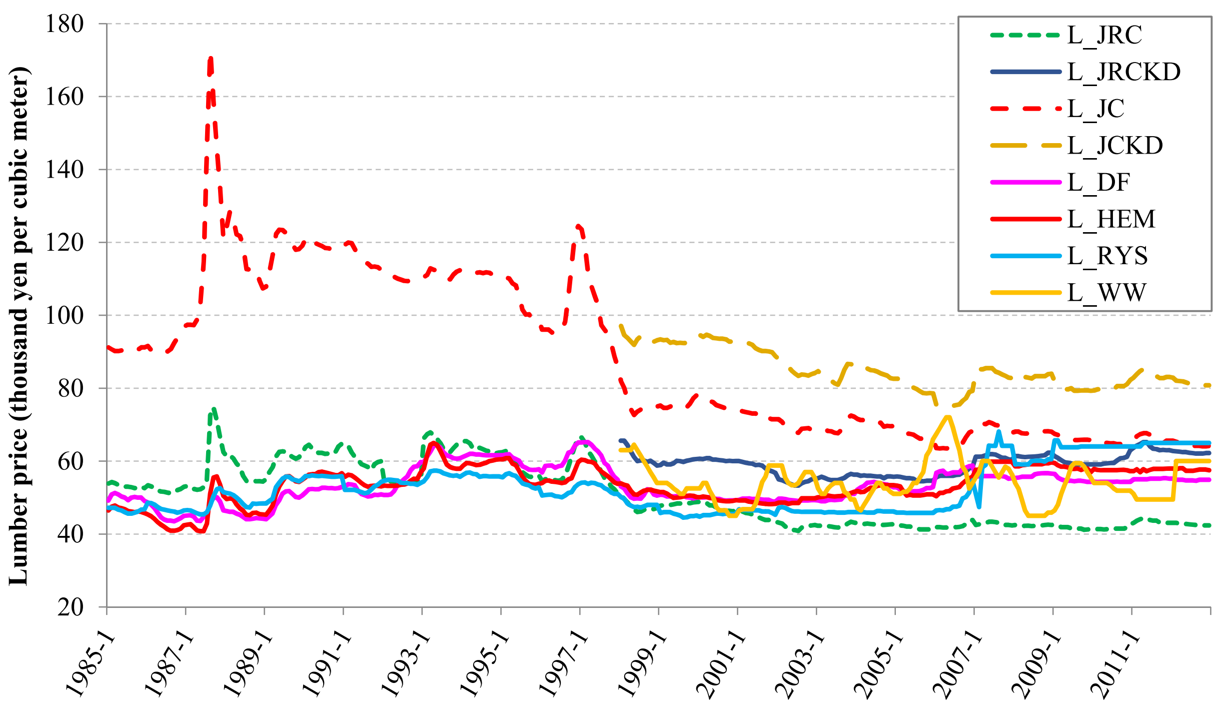

Figure 13. Lumber prices in the Japanese market, Jan. 1985 through Dec. 2012
Source: MAFF, 1985-2012. (Price series abbreviations for lumber are explained in Table 3).

Correlations

The correlation coefficients for the wood products to be analyzed provide an index measure of market integration. Correlation coefficient values near 1.0 suggest that products are in the same market, whereas values near zero suggest products are in different markets, if price series of the products are stationary. Pearson's correlation coefficients for the price series for sawlogs and lumber over time are calculated as a measure of interdependence, and reported in Table 4 through 6.

For sawlog prices for the entire period of 1985 to 2012 (Table 4), pairs of three domestic species showed a strong correlation relationship with values higher than 0.8, suggesting that these domestic sawlog species could be in the same market. Pairs of imported sawlog prices of the same origin; sawlog prices from North America (Douglas-fir and hemlock) and those from Russia (Russian larch and Russian Yezo spruce), also showed relatively higher correlation values of 0.689 and 0.780, respectively, suggesting again that imported sawlog species of the same origin are likely to be in the same market. The results on pairs of sawlog prices of different origins were more variable. Pairs of domestic and imported sawlog prices generally showed little or no correlation, suggesting that those wood species could have different markets, except for the pairs of Japanese larch and two Russian species (larch and Yezo spruce) with values of 0.577 and 0.524, respectively, whereas the pairs of hemlock and Russian species (larch and Yezo spruce) had relatively high correlations (0.789 and 0.606, respectively).

Table 4. Correlation matrix of sawlog price, Jan. 1985 to Dec. 2012.

Correlation	S_DF	S_HEM	S_JC	S_JL	S_JRC	S_RL	S_RYS
S_DF	1.000						
S_HEM	**0.689**	1.000					
S_JC	0.029	0.189	1.000				
S_JL	-0.043	0.386	**0.838**	1.000			
S_JRC	-0.013	0.225	**0.984**	**0.902**	1.000		
S_RL	0.451	**0.789**	0.277	**0.577**	0.342	1.000	
S_RYS	0.010	**0.609**	0.129	**0.524**	0.214	**0.780**	1.000

Note: Correlation values greater than 0.5 are bold for emphasis.
Price series abbreviations for lumber are explained in Table 3.

A similar trend was observed for the more recent subsample from 1992 to 2012 (Table 5), along with the fact that some additional pairs exhibited moderately higher correlation values, including price pairs of Douglas-fir and all the domestic species, Douglas-fir and Russian larch, and hemlock and Japanese larch.

Table 5. Correlation matrix of sawlog price, Jan. 1992 to Dec. 2012.

Correlation	S_DF	S_HEM	S_JC	S_JL	S_JRC	S_RL	S_RYS
S_DF	1.000						
S_HEM	**0.692**	1.000					
S_JC	**0.654**	0.371	1.000				
S_JL	**0.559**	**0.681**	**0.778**	1.000			
S_JRC	**0.658**	0.463	**0.985**	**0.847**	1.000		
S_RL	**0.570**	**0.817**	0.286	**0.672**	0.373	1.000	
S_RYS	0.129	**0.648**	-0.139	0.417	-0.031	**0.785**	1.000

Note: Correlation values greater than 0.5 are bold for emphasis.
Price series abbreviations for lumber are explained in Table 3.

For lumber prices over the entire period (Table 6), the correlation relationships were generally similar to those observed for sawlogs. High correlation values were observed among pairs of lumber prices of the same origin and less correlation among price pairs of domestic and imported lumber. The highest correlation existed between *hinoki* and *sugi* prices with a correlation value of 0.965, followed by the price pair of Douglas-fir and hemlock with 0.863. These results suggested that the product pairs of *sugi* and *hinoki* as well as Douglas-fir and hemlock are most likely in the same market, respectively.

Table 6. Correlation matrix of lumber price, Jan. 1985 to Dec. 2012.

Correlation	L_DF	L_HEM	L_JC	L_JRC	L_RYSBD
L_DF	1.000				
L_HEM	**0.863**	1.000			
L_JC	0.020	0.030	1.000		
L_JRC	0.161	0.144	**0.965**	1.000	
L_RYSBD	**0.515**	**0.718**	-0.067	-0.019	1.000

Note: Correlation values greater than 0.5 are bold for emphasis.
Price series abbreviations for lumber are explained in Table 3.

The recent subsample of lumber price data for 1998 to 2012 (Table 7), which included three additional items of kiln-dried *hinoki* lumber, kiln-dried *sugi* lumber, and European whitewood glulam, showed an interesting result. North American and Russian lumber had relatively high negative correlations with domestic species, except for kiln-dried (KD) *sugi* which had no correlation with other domestic lumber prices but moderate correlation with imported lumber prices. It was notable that the price for European whitewood glulam showed no correlation with any other prices included in the subsample, suggesting that whitewood might have a distinct market relative to other lumber products.

Table 7. Correlation matrix of lumber price, Jan. 1998 to Dec. 2012.

Correlation	L_DF	L_HEM	L_JC	L_JCKD	L_JRC	L_JRCKD	L_RYSBD	L_WW
L_DF	1.000							
L_HEM	**0.853**	1.000						
L_JC	-0.630	-0.517	1.000					
L_JCKD	-0.662	-0.473	**0.940**	1.000				
L_JRC	-0.454	-0.376	**0.870**	**0.885**	1.000			
L_JRCKD	0.374	**0.594**	0.090	0.260	0.384	1.000		
L_RYSBD	**0.693**	**0.895**	-0.585	-0.437	-0.387	**0.647**	1.000	
L_WW	0.106	0.151	0.283	0.240	0.287	0.175	-0.057	1.000

Note: Correlation values greater than 0.5 are bold for emphasis.
Price series abbreviations for lumber are explained in Table 3.

Results

Unit root test

The results for the ADF test using the price series for sawlogs and lumber in logarithmic form for both the entire sample (1985 to 2012) and the subsamples (1992 to 2012 for sawlog; 1998 to 2012 for lumber) are presented in Tables 8 and 9. Lag length and the exogenous regressor in the test regression are also provided in the tables. Three specifications of the ADF test equation, including an exogenous constant, constant and trend, and neither, were examined for each price series. One specification was selected from the three possibilities based on the statistical significance of the exogenous variables in the test equation.

For sawlog price data in level form for the entire sample (1985-2012), the null hypothesis that a unit root exists could not be rejected for any of the variables at a 5% level of significance (Table 8), although the test results for hemlock was very close to the significance level. Eventually, all sawlog price series tested were found to be non-stationary in levels. For the subsample data of sawlog price series in levels, almost all wood species had non-stationary data series although *hinoki* exhibited stationarity in its data over the period of the analysis.

Table 8. Results of augmented Dickey-Fuller tests for the price series of sawlogs in the Japanese market.

	Entire sample: 1985-2012				Subsample: 1992-2012			
Species	**c/t**	**ADF test**	**P-value**	**Lags**	**c/t**	**ADF test**	**P-value**	**Lags**
S_DF	c	-1.961	0.304	9	c/t	-3.050	0.121	9
S_HEM	c	-2.821	0.056	7	c	-1.791	0.385	5
S_JC	c/t	-2.471	0.343	9	c/t	-4.153**	0.006	12
S_JL	-	-1.306	0.177	6	c	-1.736	0.412	7
S_JRC	c/t	-2.797	0.200	12	c/t	-2.915	0.159	12
S_RL	c	-2.667	0.089	2	c	-2.099	0.245	2
S_RYS	-	-1.838	0.362	9	c	-2.210	0.203	2

Note: Asterisks denote the significant level at which the null hypothesis is rejected: * rejection at 5% level; ** rejection at 1% level. P-values are calculated based on critical values from MacKinnon (1991). Price series abbreviations for lumber are explained in Table 3.

As shown in Table 9, unit root tests on lumber prices suggested that all the price series tested were non-stationary at the 5% level of significance for the entire sample, while *hinoki* and European whitewood were stationary for the period of the subsample. Again it should be noted that some lumber price series, such as *sugi* in the entire sample and Douglas-fir in the subsample, were close to the significance level, suggesting that they might have properties similar to stationary price series.

Table 9. Results of augmented Dickey-Fuller tests for the price series of lumber in the Japanese market.

	Entire sample: 1985-2012				Subsample: 1998-2012			
Species	c/t	**ADF test**	**P-value**	**Lags**	**c/t**	**ADF test**	**P-value**	**Lags**
L_DF	c	-2.272	0.182	3	c/t	-3.369	0.059	1
L_HEM	c	-2.586	0.097	5	c/t	-2.541	0.308	2
L_JC	c/t	-3.226	0.081	6	c	-2.991*	0.038	2
L_JCKD		---			c	-2.077	0.254	2
L_JRC	c/t	-3.336	0.062	1	c/t	-2.566	0.296	0
L_JRCKD		---			c	-2.095	0.247	4
L_RYSBD	-	0.928	0.906	0	c/t	-2.612	0.276	1
L_WW		---			c	-3.060*	0.032	3

Note: Asterisks denote the significant level at which the null hypothesis is rejected: * rejection at 5% level; ** rejection at 1% level. P-values are calculated based on critical values from MacKinnon (1991). Price series abbreviations for lumber are explained in Table 3.

The ADF tests on the first-differenced price series for all sawlogs and lumber which were found to be non-stationary rejected the null hypothesis of existence of unit roots at the 1% level of probability (results not shown). Thus, these price series were found to be non-stationary integrated of order one, $I(1)$, and were used for the subsequent analysis for cointegration, whereas the price series which were found to be stationary, such as price series of *hinoki* sawlog for the subsample period and those of *hinoki* and whitewood lumber for the subsample period, were removed from the analysis.

Johansen's cointegration test

Multivariate cointegration test

Cointegration tests to detect market integration were performed on the price series which were found to be $I(1)$, integrated of order one, in the unit root tests. If all the price series in each cointegration test were found to be cointegrated simultaneously, meaning that the law of one price holds among all the price series tested and that all the markets tested are fully integrated, the maximum number of cointegration vectors could be found from the test result. Price series of sawlogs and lumber which consisted of the cointegration tests for the entire sample and the subsample period as well as the corresponding maximum number of cointegrating vectors are presented as follows:

- Sawlog price series for the entire sample (1985-2012): price series of Douglas-fir, hemlock, *hinoki*, *sugi*, Japanese larch, Russian larch, and Russian Yezo spruce, with a maximum number of cointegrating vectors of 6.
- Sawlog price series for the subsample (1992-2012): price series of Douglas-fir, hemlock, *sugi*, Japanese larch, Russian larch, and Russian Yezo spruce, with a maximum number of cointegrating vectors of 5.
- Lumber price series for the entire sample (1985-2012): price series of Douglas-fir, hemlock, *hinoki*, *sugi*, and Russian Yezo spruce, with a maximum number of cointegrating vectors of 4.
- Lumber price series for the subsample (1998-2012): price series of Douglas-fir, hemlock, kiln-dried *hinoki*, *sugi*, kiln-dried *sugi*, and Russian Yezo spruce, with a maximum number of cointegrating vectors of 5.

Tables 10 through 13 show the results of the cointegration tests. The test specification allowed for a linear deterministic trend in the data and an intercept in the cointegration equation.

For the sawlog market for both periods of the entire sample and the subsample, the null hypothesis of no cointegrating vector was not rejected at the 5% level of significance (Table 10 and 11). Thus the cointegration tests revealed that there was no cointegration vector or stationary linear combination in the sawlog market, suggesting that every price series were stochastic and moving randomly and independently regardless of the movement of the other price series over both periods of the analysis.

Table 10. Results from Johansen's cointegration analysis for sawlog prices, Jan. 1985 to Dec. 2012.

Hypothesized no. of cointegrating vectors	Eigen value	Trace statistic	5% Critical Value	P-value
$\mathbf{r = 0}$	0.118	116.84	125.62	0.151
$\mathbf{r \leq 1}$	0.068	74.72	95.75	0.554
$\mathbf{r \leq 2}$	0.058	50.94	69.82	0.597
$\mathbf{r \leq 3}$	0.045	30.79	47.86	0.678
$\mathbf{r \leq 4}$	0.025	15.48	29.80	0.748
$\mathbf{r \leq 5}$	0.016	7.01	15.50	0.577
$\mathbf{r \leq 6}$	0.005	1.53	3.84	0.216

Table 11. Results from Johansen's cointegration analysis for sawlog prices, Jan. 1992 to Dec. 2012.

Hypothesized no. of cointegrating vectors	Eigen value	Trace statistic	5% Critical value	P-value
$\mathbf{r = 0}$	0.117	84.46	95.75	0.232
$\mathbf{r \leq 1}$	0.103	53.24	69.82	0.495
$\mathbf{r \leq 2}$	0.053	25.91	47.86	0.892
$\mathbf{r \leq 3}$	0.030	12.23	29.80	0.924
$\mathbf{r \leq 4}$	0.017	4.62	15.50	0.848
$\mathbf{r \leq 5}$	0.001	0.24	3.84	0.622

The results for the lumber market for the period of the entire sample also revealed that there was no cointegration relationship among the price series tested, indicating again that every price series was stochastic, with each price series moving randomly and independent of the others, over the period of the analysis (Table 12). Contrary to the result for the entire sample, the cointegration test on the subsample of lumber price series rejected the null hypothesis of no cointegrating vector against the alternative hypothesis of existence of one cointegrating vector at the 5% level of significance (Table 13). Although one cointegration relationship was found in the data tested, full market integration of lumber from 1998 to 2012 was not confirmed since the acceptance of full market integration requires evidence of six stationary linear combinations.

Table 12. Results from Johansen's cointegration analysis for lumber prices, Jan. 1985 to Dec. 2012.

Hypothesized no. of cointegrating vectors	Eigen value	Trace statistic	5% Critical value	P-value
$r = 0$	0.094	56.71	69.82	0.350
$r \leq 1$	0.041	23.62	47.86	0.950
$r \leq 2$	0.020	9.53	29.80	0.986
$r \leq 3$	0.006	2.71	15.50	0.978
$r \leq 4$	0.002	0.57	3.84	0.452

Table 13. Results from Johansen's cointegration analysis for lumber prices, Jan. 1998 to Dec. 2012.

Hypothesized no. of cointegrating vectors	Eigen value	Trace statistic		5% Critical value	P-value
$\mathbf{r = 0}$	0.219	111.17	*	95.75	0.003
$\mathbf{r \leq 1}$	0.130	66.73		69.82	0.086
$\mathbf{r \leq 2}$	0.112	41.65		47.86	0.169
$\mathbf{r \leq 3}$	0.073	20.32		29.80	0.401
$\mathbf{r \leq 4}$	0.033	6.740		15.50	0.608
$\mathbf{r \leq 5}$	0.004	0.63		3.84	0.426

Note that asterisks denote the significant level at which the null hypothesis is rejected at 5% level. P-values are calculated based on critical values from MacKinnon-Haug-Michelis (1999).

Thus, simultaneous multivariate cointegration tests show that full market integration cannot be accepted for any of the price series samples of sawlog and lumber, but instead provide evidence that the law of one price only holds for a pair of price series of lumber for the sample period from 1998 to 2012.

Bivariate cointegration tests

To understand the price relationship between the various pairs of price series separately, bivariate cointegration tests were performed on the subsample of lumber prices where a cointegrating vector was found in multivariate test. This bivariate testing was conducted using the Johansen's cointegration test on pairs of price series

The results of the bivariate cointegration tests for the lumber price series from 1998 to 2012 are presented in Table 14. One cointegrating vector was found for the price pairs of Douglas-fir and hemlock, kiln-dried *hinoki,* and *sugi* respectively. The result that two cointegrating vectors were found in the pair of kiln-dried *sugi* and (non-kiln-dried) *sugi* indicated that the model was either misspecified in terms of determining the lag length or deterministic trend, or the price series in the model were stationary in levels, although both series were previously found to be non-stationary.

Table 14. Bivariate cointegration tests for lumber prices, Jan. 1998 to Dec. 2012.

			Eigenvalue	Trace statistic		5% Critical Value	P-value
L_DF	**L_HEM**	**r = 0**	0.109	22.76	*	15.50	0.003
		r ≤ 1	0.011	1.91		3.84	0.167
	L_JCKD	**r = 0**	0.100	21.54	*	15.50	0.005
		r ≤ 1	0.014	2.59		3.84	0.108
	L_JRC	**r = 0**	0.092	20.37	*	15.50	0.009
		r ≤ 1	0.017	3.02		3.84	0.082
	L_JRCKD	**r = 0**	0.045	14.86		15.50	0.062
	L_RYSBD	**r = 0**	0.069	13.41		15.50	0.101
L_HEM	**L_JCKD**	**r = 0**	0.074	15.25		15.50	0.054
	L_JRC	**r = 0**	0.061	12.85		15.50	0.120
	L_JRCKD	**r = 0**	0.050	12.00		15.50	0.157
	L_RYSBD	**r = 0**	0.042	8.52		15.50	0.411
L_JCKD	**L_JRC**	**r = 0**	0.062	18.08	*	15.50	0.020
		r ≤ 1	0.036	6.51	*	3.84	0.011
	L_JRCKD	**r = 0**	0.061	12.71		15.50	0.126
	L_RYSBD	**r = 0**	0.037	7.46		15.50	0.525
L_JRC	**L_JRCKD**	**r = 0**	0.044	8.66		15.50	0.398
	L_RYSBD	**r = 0**	0.050	9.68		15.50	0.306
L_JRCKD	**L_RYSBD**	**r = 0**	0.051	9.80		15.50	0.296

Note: Asterisks denote the significant level at which the null hypothesis is rejected at 5% level. P-values are calculated based on critical values from MacKinnon-Haug-Michelis (1999).

As the price series for Douglas-fir and three species were cointegrated respectively, the hypothesis of the law of one price was tested. As the unconstrained constant allowing the price difference was included in the cointegration equation, this hypothesis tested was the weak version of the law of one price (Buongiorno and Uusivuori, 1992). In testing the hypothesis, restrictions were imposed on the cointegrating vector β, i.e., the price coefficients in vector β were to be of equal magnitude but of opposite signs ($\beta_1 = 1$ and $\beta_2 = -1$).
The test results presented in Table 15 indicate rejection of the null hypothesis for all pairs tested. Consequently the law of one price was rejected for all of the price pairs tested.

Table 15. Test results for law of one price by price pairs with restriction.

Tested price pairs	H_0	LR test statistic (P-value)
L_DF and L_HEM	$\beta_{\text{L\_DF}} = 1$ and $\beta_{\text{L\_HEM}} = -1$	6.199* (0.013)
L_DF and L_JCKD	$\beta_{\text{L\_DF}} = 1$ and $\beta_{\text{L\_JCKD}} = -1$	16.188* (0.000)
L_DF and L_JRC	$\beta_{\text{L\_DF}} = 1$ and $\beta_{\text{L\_JRC}} = -1$	13.862* (0.000)

Note: Asterisks denote the significant level at which the null hypothesis is rejected at 5% level. Price series abbreviations for lumber are explained in Table 3.

Discussion and Conclusions

Since the hypothesis of market integration was rejected for almost all price pairs of sawlogs and lumber in the Japanese wood market, domestic and imported wood products tested for cointegration could not be considered to be close substitutes for each other. This was true in spite of the length of period tested. Although three pairs of lumber prices were found to be cointegrated in the bivariate test using the subsample data, the results from the pairs of Douglas-fir and two domestic species, *hinoki* and *sugi* (KD), were doubtful given the fact that correlation values for both price pairs indicated that their correlation was negative. Eventually, only the pair of Douglas-fir lumber and hemlock lumber could be considered to be integrated for the period after 1998, although the law of one price was not confirmed to hold between these products.

The absence of market integration between domestic and imported wood, and even between different species of domestic wood, for both sawlogs and lumber suggests that the products evaluated in this study could be differentiated by buyers and constitute segmented markets in Japan. This observation is further supported by the fact that specific wood species are used in specific end-use application in Japanese traditional post and beam housing construction. As indicated in the previous section, 95% of beams in post and beam houses that require high bending strength are imported wood. Additionally, several anecdotal surveys on the precut post and beam industry in Japan support the fact that particular species of lumber are preferable for beam and sill applications where high strength and decay resistance are required respectively (e.g. Eastin et al., 2003).

Thus, the assumption that domestic and imported wood are perfectly substitutable in the analysis of any trade policy for forest products is not appropriate, and the use of models that assume perfect substitutability have limited value and may lead to results that may not be correct. It can be inferred from the study results that any change in the supply of products that are species specific, such as increase in the *sugi* log supply, is not likely to affect demand for and the price of products of other species, such as the price of Douglas-fir logs, since these markets are not integrated. It is quite likely, however, that some wood species have complementary relationships given the fact that, as mentioned above, certain end-use applications require specific physical and /or mechanical properties in post and beam housing construction. If this is the case, greater use of domestic wood could lead to an increase in the demand for imported wood. Similarly, if the demand for domestic wood is elastic enough, an increase in the supply of domestic wood could also lead to increased demand for imported wood as well, although the converse could also be true. However, in the case where the demand for wood remains constant or declining (as is the case in Japan), it is likely that a substantial increase in the demand for domestic wood would necessarily result in a corresponding decrease in the demand for imported wood.

In the case of the existence of market differentiation among wood products in the Japanese market, one possible way to model the impact of the Revitalization Plan, or that of the increasing supply of domestic wood, on changes in the demand for domestic and imported wood as well as the volume of wood products traded would be to estimate the Armington (1969) elasticity of substitution. The Armington elasticity of substitution has several features, including that: 1) it is derived based on the assumption that domestic and imported goods are imperfect substitutes for each other, and 2) the model used to estimate the Armington elasticity of substitution is simple and applicable for both production and consumption (Gan, 2006). The Armington elasticity of substitution between domestic and imported wood products measures the percentage change in the ratio of quantities demanded for foreign and domestically produced forest products for a 1% change in their relative price, reflecting the ease of substitution between the domestic and imported forest products (Gan, 2006). Earlier works on estimating the Armington elasticity for wood products include Gan (2006) who estimated the elasticities between US domestic and imported wood products and Sauquert et al. (2011) who worked on estimating the elasticities between domestic and imported wood products in France. In a similar way, it should be possible to derive the Armington elasticity of substitution between Japan's domestic and imported forest products, and thus, the impact of the Revitalization Plan could be assessed.

Limitations of the study

It is important to recognize that several limitations exist in this study that affect both the results observed in the statistical tests and the inferences derived from the results. First, the wood products analyzed in this study included only sawlogs and lumber, whereas other wood products such as plywood and wood chips, were not included. This was because plywood products are hard to distinguish by origin since both domestic and imported wood could be used in the same product. As for chips, it was suspected that an efficient market does not exist since the largest demand sector for chips is the paper manufacturing industry which has oligopsony power in the chip market.

Next, the price series of each good used in the analysis is spatially aggregated at the national level, which could have made each price series lose some information about the market relationship of domestic and imported wood at the regional level: some wood products could be actually integrated in some regions.

The length and frequency of the price data might have also affected the test results, since the power of the cointegration test is affected by the number of data points. Although this study employed monthly data based on the notion by Shahi et al. (2006) that data for cointegration tests should be used at the same frequency at which it is being generated, data with different length and span may give different results. However, the inferences derived from quarterly or yearly data over a longer period of time was not included in the scope of this study where the more recent relationship between wood products was the focus of the analysis.

Two final points are that, first, a major imported lumber product was not tested for integration since the data for European whitewood glulam exhibited stationarity and thus was inappropriate for the test for cointegration. Second, the sparse availability of data sources also limited the analysis on the relationship between domestic and imported wood, since time series data on prices of some important lumber species, such as SPF from Canada and redwood (pine) from European countries, was not available in MAFF's statistical database.

Implications of Japan's wood policies

With the goal of increasing self-sufficiency, the Japanese government aims to increase the domestic wood supply, although the results of the policy may not necessarily be beneficial for forest owners in Japan. If the supply of domestic wood was increased by lowering harvesting costs and streamlining log distribution as a result of the subsidies provided by the Revitalization Plan, the prices of domestic wood would drop in the short run if a corresponding increase in demand for domestic wood did not develop. This is because, as the results indicate, domestic wood is not likely to substitute for imported wood. In fact, a sudden drop in the price of domestic logs caused by an increased supply was already observed in some regions of Japan at the beginning of FY 2012 after MAFF started the aforementioned new subsidy program to promote thinning of plantation forests. Hence, without any demand stimulation for domestic wood, a supply increase is likely to be associated with further price drops for domestic wood which already has experienced long term price declines since the 1980s.

Recognizing the importance of this, several policy measures designed to expand the demand for domestic wood were introduced within the context of the Revitalization Plan. The measures designed to expand the demand for domestic wood include: 1) the "Law Concerning the Promotion of the Use of Wood in Public Buildings" implemented in October 2010, which required that all national, prefectural and municipal governments give precedence to wood use in public buildings when possible, 2) the promotion of the use of wood biomass as renewable energy source under the Feed-in Tariff (FIT) Scheme for Renewable

Energy that was launched in 2012 and 3) the Wood Use Points Program introduced which provides subsidies to home builders who use a specified proportion of domestic wood in their homes.

MAFF projected that approximately 700,000 to 800,000 cubic meters of wood might be used annually in public buildings under the Wood Use in Public Buildings Law, although that volume is equivalent to less than 10% of the expected increase in supply projected under the Revitalization Plan, which anticipated that the annual supply of domestic wood for lumber production would increase by 8 million cubic meters (from 11 million cubic meters in 2009 to 19 million cubic meters in 2020). Additionally, the wood material used for public building construction is not limited to domestic wood (although to date more than 85% has been domestic wood), and it is possible that the demand for imported wood used in public buildings could increase incrementally in the future.

The effect of the FIT scheme on the increased demand for domestic wood is more uncertain. During the first year following the implementation of the FIT scheme in April 2012, only one project was approved to use domestic wood (logs) for power generation. This is in contrast to the higher level of investment in solar power plants under the scheme. Although several new projects using domestic wood for renewable energy source are reported to be on the way (New Energy Foundation, 2012), the impacts of these new projects in increasing the demand for domestic wood still seems to be limited.

As mentioned above, the demand for imported wood may not necessarily be adversely affected by Japan's policies designed to increase the supply of, and the demand for, domestic wood. Nevertheless, several issues have to be pointed out in this regard. First, Japanese housing starts have been decreasing and they are not expected to dramatically increase given that the Japanese population is aging and shrinking. Since lumber demand is highly dependent on the housing industry, the declining trend of housing starts will reduce the total demand for wood in Japan. Given the emphasis of the Revitalization Plan on doubling the supply of domestic wood by 2020, this will inevitably lead to a reduce demand for imported wood.

Second, as imports of logs have declined, domestic sawmills and plywood mills have been switching their raw material inputs from imported to domestic logs. This trend is being strengthened by the governmental subsidy programs that support the expansion and modernization of domestic sawmills and plywood mills to replace older processing equipment with newer, more efficient processing technology that can utilize the smaller diameter domestic logs. Thus, the share of imported logs used in domestic sawmills and plywood mills is likely to decline.

Third, Japanese macroeconomic policy could affect wood imports. In the lower house election of December 2012, the LDP won a landslide victory and returned to power. The new Prime Minister Shinzo Abe, the leader of the LDP, repeatedly insisted on achieving a target of 2% annual inflation to end two decades of deflation during the election campaign. He has been successful in having the Central Bank introduce a 2% inflation target and further loosen monetary policy. These monetary-easing measures have impacted the exchange rate by depreciating the value of the yen and the yen has depreciated by about 20% against the U.S. dollar over the first four months following Abe's election in December 2012. The exchange rate has historically had a large impact on the volume of wood imports, since a strong yen makes it possible for Japanese importers to import more foreign wood products at a lower price. Likewise, exports of wood products from the U.S. and Canada are known to be elastic with respect to the exchange rate (Bolkesjøa and Buongiorno, 2006). Thus, the depreciation of the yen as a result of Japan's change in monetary policy is likely to lead to a decline in total wood imports into Japan.

Lastly, and potentially most importantly, government subsidy programs targeted to expand the use of domestic wood may distort the market relationships found in this study. In early 2013, MAFF announced a plan to introduce the "Wood Use Points Program" which aims to increase the demand for domestic wood products by giving a considerable amount of points (300,000 points valued at 300,000 yen) which have monetary value for new home buyers who purchase homes built with a specified amount of local wood. It is likely that many builders and consumers will take advantage of the Wood Use Points Program. If this is true, then the huge subsidies provided by the program would effectively expand the demand for domestic wood at the direct expense of imported wood. Since governmental subsidy programs in Japan are often extended beyond their original time frame, the adverse impact of the Wood Use Points Program on the demand for imported wood could be tremendous.

Conclusions

This study examined the existence of a cointegration relationship between domestic and imported wood using price series of sawlog and lumber in order to understand the competitive relationship between them in Japanese market. Using Johansen's multivariate cointegration tests, it was revealed that domestic wood market and imported wood market had no cointegrating relationships. Based on the findings, it was concluded that the market for domestic wood and that of imported wood are not closely connected through price arbitrage and that a price change for one wood product would not necessarily affect the prices of other wood products directly. Thus, any single policy measure focused on increasing the domestic wood supply might not have a direct effect on the demand for imported wood products. However, the inferences derived from the results relate only to the price movements over the past several decades and do not necessarily reflect the rapidly changing situation in the domestic wood industry including the massive subsidies to improve the wood processing technology within the sawmill and plywood industries as well as changes in consumer's preferences for domestic wood products as a result of the large subsidies provided under the Wood Use Points Program. These numerous subsidy programs could have a huge negative impact on the demand for imported wood products in Japan. Further research on the competitive relationship between domestic and imported wood (e.g. the Armington elasticity of substitution) should allow for better understanding on the impact of Japan's policy measures.

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