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WORKING PAPER

IMPROVING THE FORESTS DATABASE TO SUPPORT SUSTAINABLE FOREST MANAGEMENT: DOMESTIC TIMBER PRICES AND RENTAL RATES

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1 EXECUTIVE SUMMARY

The comprehensive wealth program maintained by the World Bank's Environment and Natural Resources Global Practice provides indicators to measure the sustainability of a country's growth path. These indicators include data on comprehensive wealth estimates, including data on natural resource rents, and are meant to provide policymakers with concrete information on potential revenues from natural capital. This information can be used to understand these potential future revenue streams, and can also provide information about how surplus resources are allocated as wealth changes with development.

Current estimates of wood wealth are likely overestimated, however, because they rely on exported timber values as reported by the United Nations' Food and Agriculture Organization (FAO), while prices for timber used domestically are typically quite a bit lower, sometimes by many times (Siikamaki and Santiago-Avila 2014). In this study, we used primary data on domestic timber prices collected directly from in-country sources to create regional adjustment factors for wood wealth that can be used by the World Bank in its comprehensive wealth program. These ratios can be applied to the country-level timber export data as published by FAO in order to create adjusted estimates of wood wealth that reflect more accurately the value of timber production at the global scale.

Since domestic timber prices are almost always substantially lower than the export unit values (EUV's) published by FAO, the use of these new ratios will result in smaller values of wood wealth globally, with values ranging from 26 to 67% of the wood wealth values published in years past. Because they are developed from standard methods using in-country, reliable sources, however, we find that these ratios do result in a more accurate estimate of wood wealth than the methods currently being used by the Environment and Natural Resources Global Practice.

We compare results developed in this way with results generated from commercially-available datasets such as the Wood Resources Institute (WRI) Wood Resources Quarterly (WRQ) dataset, and we explain how the updated ratios can be applied in the context of the World Bank's national wealth accounts.

2 PROJECT DESCRIPTION

BACKGROUND AND INTRODUCTION

The World Bank's Environment and Natural Resources Global Practice maintains the comprehensive wealth program, which provides indicators to measure the sustainability of a country's growth path. These indicators include data on comprehensive wealth estimates, including data on natural resource rents, and have been published for 1995, 2000, and 2005. The indicators are meant to provide policymakers with concrete information on potential revenues from natural capital that can be used to understand these potential future revenue streams, as well as information about how surplus resources are allocated as wealth changes with development.

The World Bank is in the process of reviewing and improving the current forest wealth assessment methodology to enable more accurate estimates of forest wealth and related indicators. This activity takes a two-phased approach: Phase 1 (completed in June 2014) culminated in a scoping report (Siikamaki and Santiago-Avila 2014) and Phase 2, of which this study is a part, involves implementation of the updated forest database.

In order to improve the data and methodology for the quantification of forest wealth for use in World Bank operations, and as supporting data for the policy dialogue on sustainable forest management, Applied Geosolutions (AGS) undertook a detailed analysis of timber prices and rental rates for key timber-producing countries worldwide. Data were collected from primary country-level data sources, and were compared with the Export Unit Values (EUV) provided by the Food and Agriculture Organization of the United Nations (FAO), which are currently used by the World Bank for this purpose.

The ultimate goal of this work is to develop adjustment factors that can be used by the World Bank to create more accurate estimates of forest wealth for countries based on the easily-accessible and publicly available FAO dataset. This report summarizes the Methods, Results, and Conclusions developed based on this work. A detailed description of the data and data sources used for each country appears in the Appendices. We also explain in detail how the World Bank might apply these values as it updates the forest wealth values in its comprehensive wealth database.

CURRENT METHODOLOGY

As explained in Siikamaki and Santiago-Avila (2014) "the Food and Agriculture Organization (FAO)'s statistics division is the main data source for the current forest wealth assessment. FAO's Forest Resources Assessment (FRA) provides a report every five years on global forest resource statistics. FAOSTAT–Forestry provides annual production and trade estimates for numerous forest products, such as roundwood, sawnwood, wood panels, and pulp and paper. Historical data are available from 1961 for many of these. Estimates are

provided by countries through an annual survey conducted by FAO's Forestry Department in partnership with the International Tropical Timber Organization (ITTO), the Statistical Office of the European Communities (Eurostat), and the UN Economic Commission for Europe (UNECE)."

Wood wealth is calculated as the net present value of rents from the production of timber products, discounted at 4 percent over the estimated lifetime of the forest. More specifically, wealth for country *c* in year *t* is estimated using the following formula:

$$W_{CT} = \sum_{t}^{T} \frac{(TR_{ct} * RR_{c})}{(1+r)^{t}} \quad (1)$$

where, *W* = wood wealth ($),
TR is total timber gross revenue ($),
RR is the regional rental rate (% of gross revenue),
r is the discount rate, set at 4%, and
T is the length of the discounting time horizon (25 years or the number of years to resource exhaustion).

Timber revenue (TR) for country c in year t is estimated using the following formula calculated as a lagged 5-year average:

$$TR_{ct} = \sum_{i}\left(\left(\tfrac{1}{5}\right)\sum_{t-4}^{t}\left(H_{cti} * P_{cti}\right)\right) \quad (2)$$

where H is timber harvested (production (m^3)),
P is price, calculated as the Export Unit Value (EUV) (constant $/$m^3$), and
i is the timber product (industrial roundwood, chips and particles, or woodfuel).

Total gross revenue is defined as the product of total production and unit price. In order to obtain total gross revenue values, for each of the timber product categories annual production data (in m^3) are multiplied by unit prices (export unit values, or EUV), both obtained from FAOSTAT-Forestry.[1]

Finally, the World Bank forest wealth assessment requires information on net revenues from forestry. Thus, the total revenues from timber must be adjusted: net revenues are found as the difference between total gross revenues and costs. Since we cannot estimate net revenue directly at the country level, we use an estimated rental rate to determine net timber revenues as a proportion of gross revenues. **Rental rate** (RR) is determined as the ratio of the difference in total revenue and total cost to total revenue, as follows:

$$RR = \left(\frac{Total\ \ Revenue - Total\ \ Cost}{Total\ \ Revenue}\right) \quad (3)$$

Data are limited for quantifying rental rate by country or product group. Instead of calculating these values directly, regional rental rates, based on country case studies in consultation with World Bank forestry experts, are used (Table 1) (Siikamaki and Santiago-Avila (2014).

1 Additional details on the current wood wealth methodology for timber and non-timber products alike can be found in Siikamaki and Santiago-Avila (2014).

TABLE 1. REGIONAL RENTAL RATES FOR TIMBER PRODUCTION CURRENTLY USED IN WORLD BANK FOREST WEALTH ASSESSMENT

REGION	RENTAL RATE (COSTS AS SHARE OF GROSS REVENUE)
Sub-Saharan Africa	0.41
East Asia and Pacific	0.39
Eastern Europe and Central Asia	0.40
Western Europe	0.50
Latin America and the Caribbean	0.58
Middle East and North Africa	0.55
North America	0.42
South Asia	0.50

WEAKNESSES OF CURRENT METHODOLOGY

The Scoping Report completed in June 2014 identified several weaknesses in the current methodology for estimating forest wealth (Siikamaki and Santiago-Avila 2014). Specifically, the use of Export Unit Values for valuing all timber (including timber that is used domestically) likely results in an overestimate of timber revenue, because domestic prices tend to be substantially lower than prices for exported logs. An analysis of domestic and exported timber prices for the Baltic Region for the five years between 2007 and 2012 revealed that the ratio of domestic: exported timber prices ranged from 0.226 to 0.429 (Siikamaki and Santiago-Avila 2014). This is important, as there is a direct relationship between roundwood value and wood wealth: any overestimate in roundwood prices will be translated directly into an overestimate of wood wealth.

An additional opportunity for improvement over the current methodology is in the documentation of rental rate constants. These values are based on a literature review, but the documentation on which they are based is somewhat vague and the literature used to generate them is outdated (Siikamaki and Santiago-Avila 2014).

UPDATED APPROACH IN THIS STUDY

In this study, we sought to improve the World Bank methodology for forest wealth estimation, by developing methods that would work around these potential shortcomings. First, we collected domestic timber price data for a subset of countries (see Table 2) and compared this to the EUV's from FAO, as well as to the data derived from the Wood Resources Quarterly (WRQ) dataset produced by Wood Resources International LLC (WRI).[2] We then used these updated price data to develop updated regional rental rate constants that utilize current costs of production, are documented transparently, and can be applied to the EUV dataset already in use by the World Bank.

The approach used in this study begins with estimates of domestic log prices for selected countries. We converted those prices to stumpage values by subtracting country-specific estimates of the costs of harvesting and delivering timber to mills. The stumpage prices can then be used directly to determine the value of annual timber flows in a country, and consequently the value of the forest stock.

2 Data from Wood Resources International are available at www.woodprices.com.

DOMESTIC VERSUS EXPORTED TIMBER PRICES

The first step in this study was to collect information on domestic timber prices from primary sources for as many countries as possible. A list of the countries for which we were able to collect data, as well as the types of data sources available, is shown in Table 2.

TABLE 2. COUNTRIES AND REGIONS FOR ANALYSIS OF EXPORTED: DOMESTIC TIMBER PRICES

COUNTRY	DATA SOURCES	PROPORTION COMPLETED
North America		
United States	WRI; Various state level reports	100%
Canada	WRI; Various province level reports	100%
Europe		
Finland	Government sources	100%
Germany	WRI	100%
Russia	WRI	100%
Asia		
China	WRI; Government sources	100%
Malaysia	Government sources	100%
Thailand	Data not available	0%
Indonesia (added)	International Tropical Timber Organization (ITTO)	100%
Vietnam (added)	Data not available	10%
Nepal	Data not available	10%
India	International Tropical Timber Organization (ITTO)	100%
Oceania		
New Zealand	WRI; Government sources	100%
Australia	WRI; Government sources	100%
Latin America		
Guatemala	Data not available	10%
Costa Rica	Government sources	100%
Argentina	Government sources	100%
Bolivia	Data not available	0%
Brazil	WRI; Government sources	100%
Chile	WRI; Government sources	100%
Guyana	Government sources	100%
Africa		
Tanzania	Data not available	0%
South Africa	Data not available	0%
Ghana	International Tropical Timber Organization (ITTO)	100%

To estimate the value of timber revenues and forest wealth for countries where data were not available from primary sources, we adjusted the value of exports downward by applying a regional ratio of the value of domestic timber to the value of exports based on the countries for which we do have data (Table 3). In other words, the countries for which we have collected primary data are assumed to provide a reasonable estimate, by region, of the ratio of the value of stumpage to the value of exports.

To summarize: for most countries of the world, we know the value of exports based on EUV data from the UN Food and Agricultural Organization (FAO). We use a regional adjustment factor to calculate the value of standing timber for each country. This regional adjustment factor is based on the countries in our sample and is our estimate of the ratio of the value of domestic timber to the value of export timber for those countries. A detailed description of the methodology appears in the next section.

In order to create regional ratios of exported: domestic timber prices, we collected domestic timber price data from primary, in-country sources.

Countries sampled

Most of the timber harvested worldwide comes from just a few key timber-producing countries, including Canada and the US, as well as European countries like Norway, Finland, Sweden, France, and Germany. In addition, substantial amounts of timber are harvested in Russia, Japan, Indonesia, Australia and New Zealand, as well as Brazil and Chile. Most of the wood exported is softwoods and tropical timber, though hardwoods may also be used domestically. The market for secondary products like wood pellets is also robust both domestically and on the export market, though this project is intended to address domestic prices for roundwood rather than the market for secondary products.

We collected domestic price data for the countries listed in Table 2, which represent a number of key timber-producing countries worldwide. We note that we have provided a full listing of all countries from which we intended to find data, but we were not able to obtain domestic timber price data directly from primary sources for some of the countries. Additional information on the sources themselves can be found in Appendix A.

Data collection methodology

Domestic price data were collected from primary domestic sources between January and April 2015 from a variety of sources, including publicly-accessible websites, personal contacts, and published reports. We sought the highest quality data available. Wherever possible, we used government-provided sources (Forestry Commission, Ministry of Agriculture, etc.). Our preference is to use government data if possible since these data have a higher likelihood, in our judgment, of being collected and published in the future using consistent methodology. In some cases, however, we used data provided by a reputable non-government organization (NGO), or by industry groups. In all cases, we valued consistency and transparency. In terms of consistency, we chose data that had been collected for multiple years using the same methods over time. Wherever possible, we included the full time series of data available in order to provide context and comparison. In terms of transparency, we chose data that could be associated with appropriate metadata, and we opted for data whose organizational structure was transparent over data that were less well organized or more difficult to understand.

In addition, we purchased data from Wood Resources International LLC.[3] Wood Resources International collects log price data for key timber-producing countries around the world. They have a long-established reputation within the

3 Available at http://woodprices.com.

wood products industry and provide data on prices for a number of market analysis companies. The WRI dataset focuses on domestic coniferous logs, but in some countries where adequate markets exist for non-coniferous logs, they provide data on those timber types as well.

Estimation of delivered log prices

Domestic timber price data were transformed in order to achieve the final unit of analysis for inclusion in the database, which was US$ per m^3. In many cases, countries provided data directly in US$. Where we converted currency into US$, local currency values were converted to US$ at market exchange rates for the year in question (i.e., nominal). For timber prices, we averaged across species and regions within countries to obtain one national level domestic price value. Where available, we used quantities to weight prices across species or regions (i.e. species and regions with the greatest harvest were weighted more heavily in the analysis). Quantity was not available in all cases, so in some cases we used simple averages. Specific details about data collection methodology, data sources, and the like for each country in our data set are provided in Appendix A.

The summary ratios of domestic delivered log prices to export prices for the countries in our database are provided in Table 3. International prices in all cases are the export prices (EUV values) from the FAO database. For countries where domestic log prices were available from both WRI data and in-country primary sources, we report ratios in Table 3 that are calculated using both data sources. The values in the far left hand column of Table 3 are production weights, which describe the relative volume of timber output from each of the countries in the region relative to the total volume output of all the countries in the region. These production weights sum to 1 for each region.

Domestic delivered log prices reflect the value of wood delivered to a mill or other log marketing location. These include the value of the stumpage plus the costs of harvesting and delivering the logs to the processing facility. Stumpage value is the value of standing trees. In general the relationship between stumpage prices and log prices is:

$$P^{Log} = P^{Stumpage} + C^{Harvest} + C^{skidding\ and\ loading} + C^{transporting} \quad (4)$$

Estimation of stumpage prices

To estimate resource rents using domestic price data, one needs to convert the delivered log prices to stumpage prices. Given the equation above, stumpage prices are determined as:

$$P^{Stumpage} = P^{Log} - C^{Harvest} - C^{skidding\ and\ loading} - C^{transporting} \quad (5)$$

To make this conversion, we need to obtain data on harvest, skidding and loading costs and transportation. These costs will vary by region due to a variety of factors, including the technology used to harvest wood, the quality of the transportation network, and other factors. We began with the data described in a literature review of cost estimates in Sohngen et al (2009) and initially attempted to update these cost estimates with newer literature. We did not find many good examples of harvesting cost estimates in the published literature, however.

We opted instead for an alternative approach to estimate harvesting and transportation costs for different regions. To do this, we calculated costs for typical harvesting operations in the United States using the Fuel Reduction Cost Simulator (Fight et al. 2006). This simulator is available in a spreadsheet form and the cost inputs for labor, fuel, and interest rates are updated for 2009 to determine a standard harvesting cost estimate for the United States.

The year 2009 is used since our estimates for timber prices include primarily the years 2009–2013. For the US, we then adjust the costs in each year from 2009 to 2013 using the logging industry producer price index from the US Bureau of Labor Statistics (series ID PCU1133—1133).[4]

The more complex set of adjustments involves converting these costs for the US to cost estimates for other countries. To do this, we use two sets of adjustments. To make the first adjustment, we adjusted costs for country-to-country differences in labor rates. We assumed that the difference in gross domestic product per capita calculated at market exchange rates represents the ratio of labor cost differences for each country relative to the US. From the data contained in Fight et al. (2006), we know that a 1% increase or decrease in labor costs will lead to a 0.23% increase or decrease in total harvesting costs. Thus, if a certain country has per capita GDP that is 25% of the per capita GDP in the US (calculated at market exchange rates), the harvesting costs in that country will be adjusted downward by 25*0.23, or 6%.

In addition to these differences in labor costs, we also account for productivity differences across economies by adjusting for the purchasing power of local currency. The productivity shock for country "i" is calculated as:

$$\text{Productivity Shock}_i = [\text{GDP(MER)}i / \text{GDP(PPP)}_i] - 1 \quad (6)$$

Where GDP is the gross domestic product of the country in US$ at market exchange rates (MER) divided by the gross domestic product measured in US$ at purchasing power parity (PPP). If GDP calculated at market exchange rates is greater than GDP calculated with purchasing power parity, then it is relatively more expensive to do business in a country. So, for example, if the ratio for a given country is 1.2, this suggests that it takes about 1.2 US$ to buy in that country what 1 US$ would buy in the US.

Using productivity shocks estimated this way for each country, we adjust harvesting and transportation costs in US$ up or down for each country relative to US harvesting costs. Data on gross domestic product at market exchange rates and purchasing power parity are obtained from the World Bank (2015).[5] Of course, harvesting costs would likely differ according to other factors, such as the terrain and the technology used, but we do not have sufficient information on each country to make adjustments for these. Cost estimates are shown in Table 4 for domestic and export harvesting and transportation costs. The main difference in the cost estimates is that we have assumed an 80 km haul for the domestic costs and a 300 km haul distance for the export costs.

ESTIMATION OF NATURAL RESOURCE RENTS

For the countries in our sample for which domestic price data were available directly (Table 1), natural resource rents can be calculated directly from estimates of domestic and export stumpage prices applied to annual timber revenue, following the methods discussed in (Siikamaki and Santiago-Avila 2014). Natural resource rents for timber reflect the value of timber produced annually within a country, i.e. the annual returns from forestry.

Using timber production data from the FAO to provide information on domestic timber consumption and net exports, as well as the stumpage prices we have estimated, we can calculate annual natural resource rent for country i:

4 Available at http://www.bls.gov.

5 Available at http://data.worldbank.org/.

TABLE 3: RATIO OF DOMESTIC DELIVERED LOG PRICES TO INTERNATIONAL PRICES, BASED ON DOMESTIC PRICE DATA COLLECTED FOR THIS STUDY (LEFT COLUMN) OR WOOD RESOURCES INTERNATIONAL (WRI) DATA (RIGHT COLUMN), OR BOTH (WHERE AVAILABLE) FOR SELECTED COUNTRIES. INTERNATIONAL PRICES ARE EXPORT PRICES (EUV) FROM THE FAO DATABASE

		CONIFEROUS		NON-CONIFEROUS		AVERAGE	
Weight	Country	Domestic/ International	WRI/ International	Domestic/ International	WRI/ International	Domestic/ International	WRI/ International
Latin America/Caribbean		**0.58**	**0.42**	**0.61**	**0.34**	**0.55**	**0.38**
0.06	Argentina	0.32		0.32		0.32	
0.73	Brazil	0.69	0.41	0.62	0.38	0.66	0.39
0.20	Chile	0.21	0.48		0.20	0.21	0.34
0.01	Costa Rica	1.05		1.61		1.33	
0.00	Guyana	0.94		1.06		1.00	
Western Europe		**0.86**	**0.71**	**0.87**	**0.73**	**0.87**	**0.72**
0.51	Finland	0.86	0.72	0.87	0.94	0.87	0.83
0.49	Germany		0.69		0.51		0.60
Eastern Europe			**0.35**		**0.39**		**0.37**
1.00	Russia		0.35		0.39		0.37
North America			**0.35**		**0.30**		**0.33**
0.68	US		0.25		0.13		0.19
0.32	Canada		0.58		0.67		0.62
East Asia and Pacific		**0.57**	**0.41**	**0.49**	**0.31**	**0.55**	**0.31**
0.20	Indonesia			0.54	0.19	0.54	0.19
0.07	Malaysia			1.40		1.40	
0.56	China	0.58		0.36		0.47	
0.09	Australia	0.67	0.42	0.54	0.58	0.61	0.50
0.09	New Zealand	0.39	0.39			0.39	0.39
Africa		**0.96**		**0.34**		**0.65**	
1.00	Ghana	0.96		0.34		0.65	
South Asia		**0.36**		**0.34**		**0.35**	
1.00	India	0.36		0.34		0.35	

TABLE 4: HARVESTING COST ESTIMATES FOR DOMESTIC AND EXPORTED TIMBER FOR COUNTRIES IN THIS DATASET. THESE COSTS ARE INCLUSIVE OF THE COSTS OF HARVESTING, SKIDDING, LOADING, AND TRANSPORTING TIMBER

	DOMESTIC HARVESTING AND HAULING TO MILL					EXPORT HARVESTING AND HAULING TO PORT				
	2009	2010	2011	2012	2013	2009	2010	2011	2012	2013
	US $ per m3					US $ per m3				
United States	$41.00	$45.30	$47.36	$48.95	$50.98	$53.00	$58.56	$61.22	$63.27	$65.90
Canada	$42.51	$52.95	$58.48	$60.12	$62.63	$51.26	$56.64	$59.21	$61.20	$63.75
Finland	$50.82	$53.96	$59.52	$57.46	$59.86	$53.03	$58.59	$61.25	$63.30	$65.94
Germany	$43.76	$45.50	$48.94	$46.80	$48.75	$51.53	$56.94	$59.52	$61.52	$64.08
Russia	$11.42	$14.84	$17.60	$18.07	$18.83	$32.32	$35.71	$37.33	$38.58	$40.19
China	$7.93	$9.34	$10.86	$11.43	$11.90	$22.17	$24.50	$25.61	$26.47	$27.57
Malaysia	$9.29	$11.71	$13.23	$13.60	$14.16	$30.26	$33.44	$34.95	$36.13	$37.63
Thailand	$17.72	$19.58	$20.46	$21.15	$22.03	$22.90	$25.30	$26.45	$27.34	$28.48
Indonesia	$12.43	$13.74	$14.36	$14.84	$15.46	$16.07	$17.76	$18.56	$19.18	$19.98
Vietnam	$6.66	$7.36	$7.70	$7.95	$8.29	$8.61	$9.52	$9.95	$10.28	$10.71
Nepal	$6.66	$7.36	$7.69	$7.95	$8.28	$8.61	$9.51	$9.94	$10.28	$10.71
New Zealand	$36.00	$39.77	$41.58	$42.97	$44.76	$46.53	$51.41	$53.75	$55.55	$57.86
Australia	$40.10	$44.30	$46.31	$47.87	$49.86	$51.83	$57.27	$59.87	$61.88	$64.45
Guatemala	$14.05	$15.52	$16.23	$16.77	$17.47	$18.16	$20.07	$20.98	$21.68	$22.58
Costa Rica	$22.18	$24.50	$25.62	$26.47	$27.58	$28.67	$31.68	$33.11	$34.22	$35.65
Argentina	$25.88	$28.60	$29.89	$30.89	$32.18	$33.45	$36.97	$38.64	$39.94	$41.60
Bolivia	$9.89	$10.93	$11.42	$11.81	$12.30	$12.78	$14.13	$14.77	$15.26	$15.90
Brazil	$24.73	$27.33	$28.57	$29.53	$30.75	$31.97	$35.33	$36.93	$38.17	$39.76
Chile	$26.54	$29.32	$30.65	$31.68	$33.00	$34.31	$37.91	$39.63	$40.95	$42.66
Guyana	$13.68	$15.11	$15.80	$16.33	$17.01	$17.68	$19.54	$20.42	$21.11	$21.99
Tanzania	$6.66	$7.36	$7.69	$7.95	$8.28	$8.61	$9.51	$9.94	$10.28	$10.71
South Africa	$21.45	$23.70	$24.78	$25.61	$26.67	$27.73	$30.64	$32.03	$33.10	$34.48
Ghana	$5.56	$6.15	$6.42	$6.64	$6.92	$7.19	$7.94	$8.30	$8.58	$8.94
India	$5.99	$6.62	$6.92	$7.15	$7.45	$7.74	$8.55	$8.94	$9.24	$9.63

$$\text{Annual Natural Resource Rents}_i \text{ (ANNRi)} = \Sigma_d P_d^S * Q_d + \Sigma_e P_e^S * Q_e \quad (7a)$$

Where P_d and Q_d are domestic timber price and the quantity of timber used domestically (m^3) and P_e and Q_e are export price and the quantity of timber exported (m^3). This calculation adjusts rents in country i for the relative proportion of coniferous and non-coniferous timber, as well as the relative amount of wood that is harvested and consumed domestically versus exported. We do not have coniferous and non-coniferous domestic stumpage prices for all countries, so we use the same price for each in cases where there is only one price estimate. Also, we do not have prices for various classes of timber, such as sawlogs, veneer logs, pulp logs, and chips, so we use the same value for each of these classes.

Finally, while we have attempted to provide domestic timber price data for all years from 2009 to 2013 for our dataset, we have not been able to obtain local timber price data for all years in some countries. When calculating the five-year average annual resource rents, therefore, we average only over the years for which we have domestic timber price data.

We calculate annual natural resource rents for the countries in Table 1 using both price approaches: first, accounting for the domestic and export stumpage prices together, and then, using the exported prices only. We find that natural resource rents calculated using domestic timber prices are substantially lower than the natural resource rent values calculated using only the exported prices (Table 5). Note that for countries where data are available from both country level sources and the WRI dataset (see Table 3), the values in Table 5 are averaged. This ratio—rent calculated using domestic prices over rent calculated using export prices—varies by country and region, but the regional average values are never greater than 0.26 (Table 5). The ratio for any particular country can be calculated as

$$\text{Ratio} = \left(\Sigma_d P_d^S * Q_d + \Sigma_e P_e^S * Q_e\right) \Big/ \left(\Sigma_d P_e^{\log} * Q_d + \Sigma_e P_e^{\log} * Q_e\right) \quad (7b)$$

In its country-level estimates of forest wealth, the World Bank can use this ratio (Table 5) to adjust natural resource rent values based on export prices (EUVs obtained from FAO data) to a more accurate value that accounts for domestic timber prices and production, as described below.

Using the estimates to create the updated wood wealth database

The ratios in Table 5 above can be used to adjust estimates of export valuations for various countries to domestic and export stumpage values.

This method follows calculations as proposed by Siikamaki and Santiago-Avila (2014), although because we calculate the ratio of rents using domestic prices versus export prices (ratio), our calculation differs from theirs. Specifically, our estimate of annual natural resources rent is:

$$\text{Annual Natural Resource Rents}_i \text{ (ANRR*}_i) = (\text{Total Revenue}_i)*\text{Ratio} \quad (8)$$

Where the total revenue is total wood production of country "i" valued at export prices (EUV's) obtained from UN FAO. These data are publicly available and accessible for most countries of the world. The ratio in equation (8) is defined in equation (7b), and the regional ratio estimates are provided in Table 5. This calculation will adjust the total revenues, valued at export log prices, for any country in the particular region to the stumpage value, as it has been adjusted to account differentially for the value of domestically consumed versus exported timber. For countries not listed specifically in Table 5, we recommend using the ratio for the region to which the country belongs.

TABLE 5: CALCULATION OF AVERAGE NATURAL RESOURCE RENTS CALCULATED WITH EQUATION (7A) ABOVE (WEIGHTED BY DOMESTIC AND EXPORT CONSUMPTION), AND CALCULATED USING ONLY EXPORT LOG VALUES

		AVERAGE NATURAL RESOURCE RENTS		
Weight	Country	Calculated with domestic and export stumpage values (from Equation 7)	Calculated with export log values (also Equation 7 but ignores domestic prices & stumpage)	Ratio
		US $/yr		
Latin America/Caribbean		**$4,378,531,583**	**$19,079,951,277**	**0.24**
0.06	Argentina	$392,824,656	$2,042,540,466	0.19
0.73	Brazil	$5,635,140,422	$24,100,047,189	0.23
0.20	Chile	$1,204,195,474	$6,815,075,991	
0.01	Costa Rica	$162,501,303	$237,614,245	0.68
0.00	Guyana	$78,450,729	$81,442,631	0.96
Western Europe		**$655,302,586**	**$3,895,579,430**	**0.17**
0.51	Finland	$490,506,032	$3,378,154,596	0.15
0.49	Germany	$825,858,636	$4,431,087,809	0.19
Eastern Europe				
1.00	Russia	$3,880,250,688	$15,124,639,376	0.26
North America		**$6,069,856,594**	**$46,507,836,799**	**0.11**
0.68	US	$8,519,831,910	$61,857,064,098	0.14
0.32	Canada	$905,566,207	$14,153,279,384	0.06
East Asia and Pacific		**$9,514,930,607**	**$55,508,251,587**	**0.26**
0.20	Indonesia	$2,221,582,671	$15,831,380,653	0.14
0.07	Malaysia	$4,111,114,458	$3,560,717,599	1.15
0.56	China	$15,543,054,712	$92,895,795,558	0.17
0.09	Australia	$786,705,648	$2,874,124,667	0.27
0.09	New Zealand	$949,853,256	$2,459,993,823	0.39
Africa		**$326,705,458**	**$790,154,760**	**0.41**
1.00	Ghana	$326,705,458	$790,154,760	0.41
South Asia		**$1,325,685,550**	**$13,010,977,545**	**0.10**
1.00	India	$1,325,685,550	$13,010,977,545	0.10

Updating the ratios

A substantial effort is required to locate and organize domestic timber price data collected from primary sources, even for the subset of countries where good records are available. For this reason, we do not recommend that the World Bank undertake routinely to collect domestic price data from every country. Instead, the ratios presented here are meant to provide an adequate estimate of the difference between export and domestic timber prices that can be applied at the regional scale to the publicly-available FAO dataset in future years.

The WRI dataset is a good source of timber price data, but there is not clear agreement between the data collected from primary sources and the data from WRI, even for countries where both are available (Table 3). We have

TABLE 6: COMPARISON OF ORIGINAL RENTAL RATE CALCULATED BY WORLD BANK AND RATIO CALCULATED IN THIS RESEARCH

	RENTAL RATE	RATIO
	(share of gross revenue)	
Sub-Saharan Africa	0.41	0.41
East Asia and Pacific	0.39	0.26
Eastern Europe and Central Asia	0.4	0.26
Western Europe	0.5	0.17
Latin America and the Caribbean	0.58	0.24
Middle East and North Africa	0.55	NA
North America	0.42	0.11
South Asia	0.5	0.10

incorporated both primary source and WRI data in these ratios (Table 6) by taking the average of the two domestic price estimates for countries where both types of data were available. We suggest that these ratios are appropriate for use for the near future, and might be adjusted after 10 or so years based on additional research if new sources of domestic price data become available, or if the global timber market shifts, or perhaps when the World Bank finds that the numbers are inappropriate for another reason.

DISCUSSION

The use of this ratio, thereby accounting for domestic timber production and prices instead of simply applying export values to all timber produced, will reduce the value of wood wealth for countries to roughly 26 to 67% of the values published in years past (Table 6). The "Ratio" in equation (8) was termed "Rental Rate" by Siikamaki and Santiago-Avila (2014), who also provided the set of rental rate adjustments used by World Bank in current estimates of wood wealth (Table 6). Still, it is clear that domestic prices and export timber prices do differ substantially from one another, and the previous methods did not adjust appropriately for this difference, so the methods developed here represent a clear improvement over the current approach.

Uncertainties

There are several important uncertainties in this analysis. First, we have collected domestic timber price data from only a few countries out of the large number of countries in the world. We have selected the specific countries we analyzed because they represent a significant proportion of the total timber in the region to which they are assigned, but still one can see significant variation across the countries we have analyzed, so applying the regional results to specific countries should be done carefully.

Second, we have used public or commercially available data sources, which in principle will allow for replication in the future. But we note that many public sources of data were found after significant searching on the internet, and it is not clear how well the countries will keep those sources of data up in the future.

Third, we do not have representative timber harvesting cost data for every country. We had to extrapolate data from the US to other regions. This potentially creates problems because timber harvesting in the US is technologically advanced and roads are fairly well kept up. We have adjusted costs in other regions partially for shifts in labor costs and other costs, but these adjustments are aggregate and not specific for the timber harvesting industry.

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3 APPENDIX: COUNTRY BY COUNTRY DESCRIPTION OF DATA COLLECTION, TRANSFORMATION, AND AGGREGATION PROCESS

ARGENTINA

The data used for Argentina were drawn from the Statistical Yearbook of Forest Native Species found on the government site for the National Forestry Program Statistics using several chapters of the document the Statistical Yearbook of Forest Native Species. The Statistical Yearbook of Forest Native Species contains various chapters detailing forest products of native species, manufactured products, exterior timber market comparisons, inventory of various types of forests, and indicators of variability.

The majority of data was drawn from the first and third chapters of the Statistical Yearbook, detailing Forest Products. This chapter listed production values information for logs, stumpage, boards, and wood fuel by year and production area jurisdiction. Chapter three detailed price information by native species and listed the total species for each jurisdiction by metric ton and cubic meter. However, other chapters also contained a variety of more detailed information, including secondary products, forest exports, and deforestation.

During analysis, emphasis was on the five highest volume-producing regions: Chaco, Formosa, Misiones, Salta, and Tierra del Fuego. Production values pulled from Chapter I and pricing information for listed species from Chapter III were combined to create total value of annual production for each jurisdiction in the Argentine Peso. Prices were listed in these chapters as both "rollizos" and "Monte en pie" or "puestos en industria" as well, which are two different category types for pricing (as determined by the PDF of Argentina Forestry Explanations). Monte en pie is a means of valuing the timber production by relying on a fixed price per hectare in cases where the producer has an exact idea of the volume that will be produced. This is the most common type of pricing. After collecting the pricing and quantity data, the value per species was calculated and totaled to find the total value for each jurisdiction. Then, the total weighted price average was found by totally the quantities published and then dividing the total value by the totaled quantities. Then, prices were converted into US Dollars using historical conversion rates found through the website Oanda.com

The statistical yearbooks used can be found at this link:

http://www.ambiente.gov.ar/?idseccion=217.

Other notes:

- Historical price averages were calculated using OANDA.com
- Prices assumed to be in Argentine Peso
- Price data pulled from document sections looking at "rollizos"

AUSTRALIA

The data for Australian forest production were found on the website for the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). The publication "Australian forest and wood products statistics: March and June quarters 2014" has numerous available detailed tables covering a variety of topics, including:

- Resource base
- Logs
- Wood products
- Quarterly imports
- Quarterly exports

The data most important to the analysis of the Australian timber market are the data sections "Gross value of logs harvested" and "Volume of logs harvested, by state and forest type." Both spreadsheets, found in the downloaded tables from the aforementioned publication contain ample data on the product type, wood type, forest type, regional production and pricing of wood products in Australia since 2001.The gross value of logs harvested price each log category listed below in millions of Australian dollars:

- Hardwood sawlogs
- Softwood sawlogs
- Native cypress pine sawlogs
- Plywood and veneer logs
- Wood panels pulplogs
- Export woodchip hardwood pulplogs
- Export woodchip softwood pulplogs
- Paper pulplogs

Log production in Australian was denoted by region and in Australia as a whole in thousands of cubic meters and included hardwood native and hardwood plantation, as well as softwood.

The manipulation of the Australian log data was minimal—only relying on finding the annual gross value of production using information found in both datatables mentioned above. Additionally, the value of each product type had to be converted from Australian to US dollars using historical currency conversions from Oanda.com

The publication and data tables are published at this link:

http://www.agriculture.gov.au/abares/publications/display?url=http://143.188.17.20/anrdl/DAFFService/display.php?fid=pb_afwpsd9abfe20141111_11a.xml.

BRAZIL

The Brazilian data were gathered from two different sources. The first source, the Brazilian Institute of Geography and Statistics (IBGE—Instituto Brasileiro de Geografia e Estatisticas), provides a multitude of economic,

environmental, and demographic data. The second source used to collect pricing information is the International Tropical Timber Organization, which is an intergovernmental organization that promotes the conservation and sustainable management, use and trade of tropical forest resources.

The datasets from IBGE's website were found in the research results for the "Production of the Wild Crop Harvesting and Silviculture" under the sections of Economy and Agriculture by year and contain information on the quantity and value of production arising from the processes of exploration of wild crops and forestry products. The tables can be downloaded in PDF, Excel and zipped formats on the following subjects:

- Quantity and value of the products of wild crop harvesting and silviculture, by main products.
- Quantity and value of the products of vegetal extraction, by products, by major regions and federation units (states)
- Quantity of felled trees, production of logwood, amount and value of araucaria pine knot, by major regions and federation units (states)
- Quantity and value of products from silviculture, by product, by major regions and federation units (states)
- Quantity and value of products from silviculture, by species, by major regions and federation units (states)

The data most heavily relied on were found in the annual tables for the Quantity and Value of Vegetation Extraction by Products According to Large Regions and Federal States ("Quantidade e valor dos produtos da extração vegetal, por produtos, segundo as Grandes Regiões e as Unidades da Federação"). This table breaks down wood products quantity and value for wood fuel, boards and round wood. The quantities are listed in tons, and cubic meters, respectively, with prices denoted in the Brazilian Real. This information is then broken down by region, the north, northeast, southeast, south, and central west and then further delineated by state. The years used in analysis were 2009, 2010, 2011, and 2013. The year 2012 was missing from the online datasets so an average of the years 2011 and 2013 were used in the analysis.

The data were pulled from the section, "Madeira en tora," or roundwood for each region and state for the quantities in cubic meters and value in Brazilian Reals. From here, the Percent of Brazilian Total was determined by dividing the quantity for each region and federation unit by the Brazil: Total. The Percent of Regional Total was also calculated in the same manner, dividing each federation unit quantity by the quantity listed for each unit. The Price/Cubic Meter (R$) was determined by dividing the Price (R$1000) by Quantity in Cubic Meters and multiplying by 1000, since the Price (R$1000) is listed in thousand price Reals. To convert the Price (R$1000) to the Price (US$1000), the historical average exchange rate for each year was found on Oanda.com

The second datasets are from the International Tropical Tinder Organization, an intergovernmental organization that promotes the conservation and sustainable management, use and trade of tropical forest resources. The organization was established under the auspices of the United Nations in 1986. Each month, ITTO publishes two newsletters with industry updates and prices in a variety of countries. That are recorded on their website and sent via email blast. In each newsletter, ten to thirteen countries or regions are listed, detailing timber pricing and notable market news and headlines.

The back issues of ITTO's market reports are all in PDF format, so the pricing information had to be entered into a spreadsheet format. However, all the pricing information was already listed in US Dollars, so no conversions were needed for pricing. After recording the listed prices from each publication for each log product, the averages of all species were taken to get a monthly average for each country. In some cases, some pricing information was

unavailable in some issues, leading some months to only have one price quoted instead of two. Additionally, as with all other ITTO data, the back issues for the year 2012 were missing, so averages of the years 2011 and 2013 were used in this case.

The raw data used can be found at these links:

http://www.ibge.gov.br/home/estatistica/pesquisas/pesquisa_resultados.php?id_pesquisa=45.

http://www.itto.int/mis_back_issues/.

Other notes:

- Historical price averages were calculated using OANDA.com

CANADA

The data complied and used to analyze the timber market in Canada were gathered from two sources, the World Resource Institute and historical log market reports from the government of British Columbia. The World Resource Institute Quarterly (WRQ) is a commercial resource that provides analysis of the international forest industry through reports on pricing and other market information. The British Columbia government website for Farming, Natural Resources, and Industry provides interior log market reports.

Both datasets provide only a partial look at the timber prices in Canada, as they are not as detailed as other sources. The data complied by the World Resource Institute provides quarterly pricing information for several different countries and some regions within several countries. The products listed aren't as numerous as other data sources, listing only coniferous and non-coniferous roundwood and coniferous and non-coniferous wood chips. For Canada, the WRQ only shows quarterly pricing for eastern and western Canada and has no pricing information listed for non-coniferous round wood or non-coniferous chips in western Canada. The British Columbia government website details much more in terms of pricing for wood products, providing interior log market reports from the years 2008 through 2014 in both monthly and tri-monthly time periods. Each report provides volume in cubic meters and pricing in Canadian dollars of each product, sawlog, peelers, house, minor products, pulpwood, and other products by species.

Few calculations were needed to manipulate the data. For the WRQ data, the only necessary calculations were to find the average of the first and fourth quarter pricing for each product type. The change between the first and fourth quarter, respectively, was found for each product type in each region as well. For the British Columbia data, there were also few manipulations needed. The total value for each species was found simply by multiplying the volume by the species price and rounded price values respectively.

The website to the WRQ subscription service is found at this link:

http://woodprices.com/wood-resource-quarterly/.

The British Columbia log reports can be found Here:

http://www2.gov.bc.ca/gov/content/industry/forestry/timber-pricing/interior-timber-pricing/interior-log-market-reports.

CHILE

The data used to compile pricing information for Chile were collected from an annual report published by the INFOR Forestry Institute (Instituto Forestal) of the Chilean government. The Forestry Insititute is a Technological Research institute that was created by the Chilean Ministry of Agriculture as a UN Food and Agriculture Organization project. The institute works to develop small and medium forestry and timber production while adhering to environmental and economic goals.

The data used for analysis of the timber market in Chile were drawn from the 2014 Annual Report published by INFOR and thoroughly covers a variety of topics ranging from macroeconomic indicators, forestry resources, exterior markets, prices, and development of forests. The report is very detailed and contains pricing information that dates back to 1990 by product type and species listen in US dollars for saw logs and pulp logs, as well as sawn, sized and treated wood. The report also includes some pricing information on non-timber forest products. There was also substantial pricing data listed for treated wood, organized by species, region, product type and year.

There was little manipulation needed to organize and present the data for Chile. All the pricing information was listed in US dollars and averaged annually. The years 2010 through 2013 also contained quarterly price averages. The only calculation used was to find the average log price between saw logs and pulp logs.

The report used can be found at this link:

http://wef.infor.cl/publicaciones/anuario/2014/Anuario2014.pdf.

CHINA

The data used for the analysis of the Chinese timber market were provided by a colleague of Dr. Brent Sohngen, Jintao 徐晋涛, and the Chinese Forestry Statistical Yearbook.

The data were converted from the Chinese yuan to US dollars using historical price averages found on Oanda.com.

COSTA RICA

The pricing data for Costa Rica were derived from publications at the website of the National Forest Office (Oficina Nacional Forestal). The most useful reports were the "report Uses and Contributions of Wood, Statistics…" which detailed log and sawn wood pricing for a number of species.

Each document, collected for the years 2012, 2013, and 2014, consulting approximately 100 industry managers, traders and producers to find reliable information on the timber market. The years 2013 and 2014, however, only contain market information for the first half of the calendar year. Prices are listed by 32 species in the Costa Rican colones for wood priced "en pie" (see Argentina for explanation of "en pie" pricing), in logs, and sawn wood. The sizing used is one timber inch tica, which is equivalent to a 1" X 1" X 4' pole (2.54cm X 2.54cm X 3.3m). The report then provides a bit more detail on the state of the market during each respective year.

To achieve an average of the prices listed, the data underwent a series of calculations. First, the prices were converted from Costa Rican colones to US dollars per inch tica for each product type, then to cubic meters to find

the price of each species in US dollars per cubic meter. Then, the prices of all of the species were average to find each annual average price per product type.

The link to these publications can be found here:

http://www.onfcr.org/article/usos-y-aportes-de-la-madera-en-costa-rica/.

Other notes:

- Historical price averages were calculated using OANDA.com
- Conversions were made to calculate the pricing from timber inch tica to cubic meters

FINLAND

The data used for Finland were found through the research organization Luke, which operates projects in the areas of forestry, wildlife, and agriculture. They compiled a user friendly database of roundwood prices in the Baltic Sea Region, which can be selected by country and timeline.

The database on the website was very simple to use, allowing users to select the country, price frequency, and date range for production of roundwood. Prices were listed for the following products: pine logs, spruce logs, birch logs, pine pulpwood, spruce pulpwood, and birch pulpwood. The only calculations necessary were to convert the listed prices from Euros to US dollars, using historical price conversions from Oanda.com.

The link can be found here:

http://www.metla.fi/metinfo/tilasto/roundwoodprices/roundwood_prices.html?maa=finland&raportointikohde=prices_month&alkuvuosi=2009&alkukuukausi=1&loppuvuosi=2015&loppukuukausi=1&submits=Submit.

GERMANY

Data used to profile the timber market in Germany were drawn from the World Resource Institute Quarterly. The World Resource Institute Quarterly (WRQ) is a commercial resource that provides analysis of the international forest industry through reports on pricing and other market information. Access to the service and information listed on the World Resource Institute Quarterly is granted through a paid subscription for the data.

As with other WRQ countries, there was limited detail for the data published. For the data listed for Germany, prices in US dollars were listed for three wood products: coniferous roundwood, non-coniferous roundwood, and coniferous chips. The years profiled were 2009 through 2014, analyzing changed from first to fourth quarters.

The calculations performed were to find the average of the first and fourth quarter pricing for each product type and change from the first to fourth quarter.

The website to the WRQ subscription service is found at this link:

http://woodprices.com/wood-resource-quarterly/.

GHANA

The data used for Ghana are from the International Tropical Tinder Organization, an intergovernmental organization that promotes the conservation and sustainable management, use and trade of tropical forest resources. The organization was established under the auspices of the United Nations in 1986. Each month, ITTO publishes two newsletters with industry updates and prices in a variety of countries. That are recorded on their website and sent via email blast. In each newsletter, ten to thirteen countries or regions are listed, detailing timber pricing and notable market news and headlines

The ITTO data listed for Ghana provided product types, species, size, and in some cases, price minimums and maximums. As with other country data found in the ITTO newsletter, the prices are listed nThe various product types include: domestic logs, sawnwood, veneer, and plywood. There were many species listed, such as:

- Wawa
- Odum
- Ceiba
- Chenchen
- Khava/Mahogany
- Sapele
- Makore
- Emeri
- Dahoma
- Redwood
- Ofram
- Bombax
- Afromosia
- Asanfina
- Avodire

The data were collected quarterly from the ITTO newsletter, in January, May, September, and December and an average was found for each product type (plywood, veneer, sawnwood, domestic logs) from all species listed. Then, the annual average for each product type was derived. Additionally, as with all other ITTO data, the back issues for the year 2012 were missing, so averages of the years 2011 and 2013 were used in this case.

The back issues can be found at this link:

http://www.itto.int/mis_back_issues/.

GUYANA

The data used for Guyana were found through contacting a colleague of Dr. Brent Sohngen, Pradeepa Bholanath, who is the head of the Planning and Development Division of the Guyana Forestry Commission. The Guyana

Forestry Commission is a government institution that develops and monitors strategies for conservation and forestry protection, forest management and development.

The pricing data for Guyana was not as extensive as other sources but still provided a longer timeline than other resources. The data provided by Bholanath contained log and sawn wood pricing data dating back to 1970 and quantity data on the volume of production since 1994. There were some gaps in the data for both roundwood and sawn wood as well. The prices were listed in US dollars.

There was minimal data manipulation, only to calculate a rate of change in quantity. In the final sheets provided for analysis, the total annual volume was calculated for both roundwood and sawn wood.

INDIA

The data used for India are from the International Tropical Tinder Organization, an intergovernmental organization that promotes the conservation and sustainable management, use and trade of tropical forest resources. The organization was established under the auspices of the United Nations in 1986. Each month, ITTO publishes two newsletters with industry updates and prices in a variety of countries. That are recorded on their website and sent via email blast. In each newsletter, ten to thirteen countries or regions are listed, detailing timber pricing and notable market news and headlines

The ITTO data for India contained more data than other countries listed in the newsletter. The data was divided by sawnwood and pywood further divided by species, such as:

- Plantation teak
- Merbau
- Balau
- Kapur
- Red Meranti
- Bilinga
- Redatiata Pine
- Beechwood
- Sycamore
- Oakwood
- American Walnut
- Hemlock
- Western Red Cedar

Prices were given in Indian Rupee per foot, many times with both minimum and maximum prices listed. The pricing data was taken twice per year from the newsletters, beginning in 2009, in August and December. Since the prices were listed in rupees per foot, first, conversions had to be made to change them to US dollars per foot. Then, to keep the data uniform across countries, the data had to be changed to US dollars per cubic meter for both the minimum and maximum prices, which were then averaged.

The back issues can be found at this link:

http://www.itto.int/mis_back_issues/.

INDONESIA

The data used for Indonesia are from the International Tropical Tinder Organization, an intergovernmental organization that promotes the conservation and sustainable management, use and trade of tropical forest resources. The organization was established under the auspices of the United Nations in 1986. Each month, ITTO publishes two newsletters with industry updates and prices in a variety of countries. That are recorded on their website and sent via email blast. In each newsletter, ten to thirteen countries or regions are listed, detailing timber pricing and notable market news and headlines.

Indonesian prices were listed for a few different products:

- Plywood logs (Face logs)
- Plywood logs (Core logs)
- Sawlogs (Meranti)
- Falcata logs
- Rubberwood
- Pine
- Mahoni (Plantation mahagony)

The average of all these product prices was used to create a monthly average that was analyzed to see changes in markets prices from the year 2011 to early 2015.

The back issues of ITTO's market reports are all in PDF format, so the pricing information had to be entered into a spreadsheet format. However, all the pricing information was already listed in US Dollars, so no conversions were needed for pricing. After recording the listed prices from each publication for each log product, the averages of all species were taken to get a monthly average for each country. In some cases, some pricing information was unavailable in some issues, leading some months to only have one price quoted instead of two. Additionally, as with all other ITTO data, the back issues for the year 2012 were missing, so averages of the years 2011 and 2013 were used in this case.

The back issues can be found at this link:

http://www.itto.int/mis_back_issues/.

MALAYSIA

The data for Malaysia were receive from a colleague of Dr. Brent Sohngen. The contact sent a spreadsheet containing government-collected price data from the Forestry Department Peninsular Malaysia, one of the departments of

the Ministry of Natural Resources and Environment Malaysia. The department is responsible for the management, planning, protection and development of the Permanent Reserved Forests.

The dataset used presents the average domestic price of logs by 22 listed species. The dates range from 2003 through 2012 and prices are listed in the Malaysian Ringgit. The value for quantity of each species production is also listed, in addition to the average log price (for all species) and stumpage price (for all species). The species listed are:

- Balau
- Balau Merah
- Cengal
- Merbau
- Campuran Kayu Keras Berat
- Kempas
- Keruing
- Kapur
- Mengkuland
- Tualang
- Campuran Kayu Keras Sederhana
- Meranti Merah Tua
- Meranti Merah Muda
- Meranti Kunig
- Meranti Putih
- Meranti Merah
- Mersawa
- Sepetir
- Nyatoh
- Jelutong
- Kayu Getah
- Campuran Kayu Keras Ringan

Little data manipulation was required for Malaysia, as the prices and quantities for each species were well-organized. The total value for each species and the average annual log price was calculated before being converted to the US dollar using historical currency conversions from Oanda.com.

The link to the data used can be found below:

http://www.forestry.gov.my/index.php/en/mengenai-kami-baru/perkhidmatan/harga-kayu-balak-negara.

NEW ZEALAND

The data used for New Zealand were sent by colleague Dr. Adam Daigneault, a senior economist at Landcare Research. Dr. Daigneault suggested seeking pricing information found on the Ministry for Primary Industries website for statistics and forecasting. At this site, data on Indicative New Zealand Radiata Pine Log Prices by Quarter were found and used to form the data tables for this country.

The national average pricing information listed in these tables presents quarterly data on a variety of wood products. Both logs and pulp are listed at varying quality types for both domestic and export priced products and showed the range in pricing from minimum to maximum. The data tables include annual data dating back to 1993, although only the years 2011 through 2014 were used in analysis. All pricing was listed in the New Zealand dollar.

The calculations used to manipulate the data were limited, only calculating the ranges in minimum to maximum pricing to achieve a price average. Additionally, the prices were converted from the New Zealand to US dollar using historical currency conversions from Oanda.com.

The price tables used can be found at this link:

https://www.mpi.govt.nz/news-and-resources/statistics-and-forecasting/forestry/indicative-new-zealand-radiata-pine-log-prices-by-quarter/.

RUSSIA

The data that were used to profile the timber market in Russia were drawn from the World Resource Institute Quarterly. The World Resource Institute Quarterly (WRQ) is a commercial resource that provides analysis of the international forest industry through reports on pricing and other market information. Access to the service and information listed on the World Resource Institute Quarterly is granted through a paid subscription for the data.

The data listed for Russia in the World Resource Institute Quarterly is limited, only providing information on pricing in the northwestern region of Russia. The data collected were listed for the years 2009 through 2014 and detailed pricing for coniferous roundwood and non-coniferous roundwood.

Few calculations were needed to manipulate the data. For the WRQ data, the only necessary calculations were to find the average of the first and fourth quarter pricing for each product type.

The website to the WRQ subscription service is found at this link:

http://woodprices.com/wood-resource-quarterly/.

UNITED STATES

Several sources were used to compile the data for the several states listed. Their descriptions are as follows:

Maine

Timber pricing data for Maine was gathered from the Maine Department of Agriculture, Conservation and Forestry website in their Main Forest Service Annual Reports for the years 2009 through 2013. The Stumpage Reports were the main reports used, containing the annual stumpage prices landowners received by county, product, and species. The report contained a summary report of stumpage prices for a variety of wood products including:

- Biomass
- Boltwood
- Firewood
- Palletwood
- Pulpwood
- Sawlogs
- Studwood
- Venner

The measurement of each product was varied and could be found in board feet (2.3597 cubic meters), cord (3.6246 cubic meters), and metric tons. Each product type is also subdivided by species type and listed minimum, maximum, and average prices.

Averages of each product type, including all species, was totaled for each year, listing minimum, maximum, and average prices per measurement type alongside the number of reports and average price per cubic meter.

The annual reports used can be found at this link:

http://www.maine.gov/dacf/mfs/publications/annual_reports.html#stumpage.

Mississippi

The timber price data used to profile the market in Mississippi were found on the Mississippi State University Forestry Extension Service website. This service is a collaboration between the Mississippi Agricultural and Forestry Experiment Station and the Mississippi State University Extension Service.Timber pricing from the Mississippi Timber Price Report has been collected from the years 1986 until 2004, when a quarterly commercial timber report began being recorded and made available to the university services.

The Mississippi data collected ranges from the year 2009 to 2013, collected quarterly, detailing a variety of species and product types. Pine and hardwood species are listed and priced by the ton for the following products:

- Sawntimber
- CNS
- Pulpwood
- Low, high, and mixed grade hardwood

The only calculations performed on the data were to find the annual average for each wood product for each species.

The main site listing the historic prices is found at this link:

http://msucares.com/forestry/prices/.

Missouri

Missouri timber pricing data were found on the website for the Missouri Department of Conservation, which contains archived timber price trends under their subsection of Professional Forest Management and Timber Management and Harvest. The price trends listed contain reports from years 1994 through 2010.

The pricing information for Missouri contains significant detail by comparison to other states or countries. The years used for this analysis were 2011 through 2014, detailing prices recorded in the latter half of the year, averaging prices between July through September and October through December. The data also contains a breakdown of averaging prices statewide, north stumpage prices, and southeast stumpage prices. There are several log types, such a veneer, sawlogs and stave logs for the following listed species:

- Black Walnut
- Hickory
- Mixed Hardwoods
- Oak (mixed species)
- Red Oak
- Shortleaf Pine
- Soft Maple
- White Oak

The prices were listed in "thousand board feet", with minimum, maximum, and average prices while also showing the prices from last quarter, last year and the total volume.

The modifications to this data were to convert the data pricing from thousand board feet to cubic meters, relying on a conversion rate of one thousand board feet equaling 2.3597 cubic meters.

The data tables for Missouri can be downloaded at this link:

http://mdc.mo.gov/your-property/professional-forest-management/timber-management-and-harvest/timber-price-trends/archi.

Ohio

The data for Ohio timber market pricing were collected from the Ohio State University's Forest Operations & Products Extension office, Ohio Wood Products. Timber price reports can be found on their website, collected twice each year since 2003.

The data listed in the sheets can be found organized in two ways: by grade and by region. For the sheets containing information by grade, both grade and species are detailed listing 12 species and their grades: Prime, Number 1 common, Number 2 common, and blocking. The species are listed below:

- Walnut
- White Oak
- Red Oak
- Cherry
- Hard Maple
- Soft Maple
- Ash
- Yellow Poplar
- Basswood
- Hickory
- Pine
- Other

The prices list a range of maximum and minimum prices, spring and fall averages, and spring and fall median prices in thousand board feet. In the region tables, the same pricing information is listed but by statewide averages and west, northeast, and southeast regions both with maximum and minimums in thousand board feet.

The calculations performed on this data were to calculate the annual averages of pricing by species and then find the cubic meter conversion of each annual average.

The data tables can be found at this link:

http://www.ohiowood.osu.edu/TimberReport.asp.

Oregon

The data used to profile the timber market in Oregon were found on the Oregon Department of Forestry website under working forests and timber sales. The data tables list log prices for domestically priced logs delivered to a mill by region, species, grade, value, and number of prices quoted.

The data used in the analysis for Oregon includes the species and many grades listed for each species, prices quotes from each fiscal quarter, number of submitted price quotes, and the average price per thousand board feet. The years 2009 through 2014 were examined, with listed species including:

- Douglas-fir
- Hemlock
- Spruce
- Western Red Cedar

- Red Alder
- Hemlock White Fir
- Western Red Cedar
- Port Oford Cedar
- Sugar Pine
- Ponderosa Pine
- Incense Cedar
- True Fir
- Lodgepole Pine

There were also numerous grades of quality and product type listed for each species. Prices were quoted from several different markets, listed belwo:

- North Oregon & Willamette
- Coos, Curry, Douglas Counties & Roseburg Market
- Grants Pass Unit
- Klamath Unit

In order to best use the data, annual averages were formed from the quarterly price quotes in thousand board feet for each product type. Then, the volume was converted from thousand board feet to cubic meters. A final average price of all the available grades and products was then found for each species type.

All data can be found at this link:

http://www.oregon.gov/ODF/Working/Pages/TimberSales.aspx.