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Global timber investments, wood costs, regulation, and risk

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ABSTRACT

We estimated financial returns and wood production costs in 2008 for the primary timber plantation species. Excluding land costs, returns for exotic plantations in almost all of South America – Brazil, Argentina, Uruguay, Chile, Colombia, Venezuela, and Paraguay – were substantial. *Eucalyptus* species returns were generally greater than those for *Pinus* species in each country, with most having Internal Rates of Return (IRRs) of 20% per year or more, as did teak. *Pinus* species in South America were generally closer to 15%, except in Argentina, where they were 20%. IRRs were less, but still attractive for plantations of coniferous or deciduous species in China, South Africa, New Zealand, Indonesia, and the United States, ranging from 7% to 12%. Costs of wood production at the cost of capital of 8% per year were generally cheapest for countries with high rates of return and for pulpwood fiber production, which would favor vertically integrated firms in Latin America. But wood costs at stumpage market prices were much greater, making net wood costs for open market wood more similar among countries. In the Americas, Chile and Brazil had the most regulatory components of sustainable forest management, followed by Misiones, Argentina and Oregon in the U.S.

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New Zealand, the United States, and Chile had the best rankings regarding risk from political, commercial, war, or government actions and for the ease of doing business. Conversely, Venezuela, Indonesia, Colombia, and Argentina had high risk ratings, and Brazil, Indonesia, and Venezuela were ranked as more difficult countries for ease of business.

1. Introduction

Wood production costs and national competitiveness are enduring issues in international forestry, forest products trade, and domestic production. A large amount of research, related publications, conferences, and public policies have focused on these subjects. Wood production and trade varies depending on natural and planted forest extent, manufacturing production costs, exchange rates, environmental and forest policies, trade laws, risk, and other factors. The interaction of these factors is complex, and changes periodically with loss of natural forests, new forest plantations, manufacturing capacity, country laws, and research and development.

Various studies have examined timber production trends in the world, but few have integrated a broad overview of timber production, wood costs, environmental regulation, and risk factors to assess the comparative advantage among countries. And most of the broad analyses of comparative advantage in the forestry sector have taken the form of forestry consulting reports, which are usually proprietary. Accordingly, the purpose of this research has been to analyze the principal factors affecting global wood production costs for the major wood production regions of the world that have large forest plantations, for technical, scientific, and policy discussions.

The focus on countries with plantations was based on the increasing importance of plantations for industrial wood, and the prospects that they will increase to providing as much as two-thirds to 80% of the world's industrial wood supply by 2030 [1]. Industrial forest plantations are the basic model that will be used in the future for biomass and bioenergy production, which has become one of the most widely proposed means to reduce fossil fuel consumption and adverse climate impacts. Indeed, plantations are already widely adopted for industrial fuel wood purposes in Brazil in particular, with 22% of its industrial roundwood production being used for charcoal in 2006 [2]. About 10% of wood from global planted forests is used for bioenergy now [1].

This research was intended to provide a current analysis of the global timber production situation based on new, public research. This can provide an integrated overview of timber production costs in the major forest plantation countries in the world, including new research on the major factors that affect timber production and trade – including timber investments, environmental laws, and investment risks. The results of this research provide a basis for assessing comparative advantage for wood production costs among the major forest plantation countries, and can help the private sector make investment decisions for industrial and fuel wood plantation systems and processing facilities. The results also provide information for public policy discussions and responses regarding trade, government policies, economic development, and woody biomass plantation opportunities. The research gives an overview linking technological advances in wood production and processing with the influence of macroeconomic and policy decisions made by the countries studied.

2. Methods

Collecting the diverse amount of information required for the objectives of this study required cooperation among scientists and practitioners in many countries. The research methods and analysis steps listed below required:

- Collecting of new data and calculating timber plantation investment returns for the principal plantation countries;
- estimating wood production costs for those plantation species based on this data;
- performing legal research on sustainable forestry laws for selected countries in the Americas;
- reviewing selected country risk and business climate estimates from the literature; and
- analyzing and comparing the preceding results about plantation returns and risks among the selected countries.

2.1. *Plantation investment returns*

Estimates of returns to forest plantation investments were made for the dominant forest plantation species in the world – primarly *Pinus spp*. and *Eucalytus spp*. Average forest productivity rates, rotations, forest management practices, input costs, and timber stumpage prices were determined based on the knowledge of the authors in interviews and consultations with other experts in each country. This approach drew from prior research [3–6] that estimated plantation and natural stand investment returns based on representative stands and management regimes for important timber producing countries in the world. The base cases should represent the current state of the forest practices, costs, and returns as of mid-2008, with relatively high prices of 700–800 USD^{t-1} of oil, and before the subsequent global economic recession.

Investment returns were calculated using capital budgeting techniques for typical forest management practices with good sites and good management. Better sites and management could yield significantly higher growth rates than those we assumed, and vice versa. The base case timber investment returns were made without any land costs – simply assuming that landowners had purchased forest land and are interested in reinvestment decisions. We did not use land prices to make sure that the timber investment returns were as comparable as possible among countries based on timber productivity and factor costs and prices. Land prices are ultimately important, but vary too much within a country and at the time of purchase to be consistent.

Taxes or other government policy interventions were not included in the base case. Thus the calculations reported in the study only include the base factor costs, production rates, and timber stumpage prices. These inputs and outputs are moderately uniform within a country.

We analyzed the returns to these timber investments using capital budgeting criteria of net present value (NPV), land or soil expectation value (LEV, SEV, or the Faustman formula), and internal rate of return (IRR) [7,8], with a discount rate of 8% y^{-1}. Companies often employ higher discount rates for developing countries, but we used the 8% rate so as to not confound our comparisons of NPV and LEV among countries. We developed the inputs independently as analysts for each country that we work in, and then revised them after review with other experts in our relevant country.

2.2. Wood costs and stumpage prices

Timber Mart South [9] and Agri-Fax [10] provide estimates of stumpage and delivered to mill timber prices in the United States and New Zealand, respectively. Brazil has some price reporting information available for clients of silvicultural consulting firms and the university in São Paulo. However, broad publicly available data on total wood production costs delivered to mills is generally lacking.

Our estimates of plantation investment returns provided a new means to calculate wood costs for stumpage at the given discount rate or at market prices for wood. We calculated the NPVs of timber investment returns based on input costs and stumpage prices for selected plantation investments throughout the world. Compounding these regeneration and management costs into the future at the discount rate provided a new means to estimate wood production costs per unit. The net future value (NFV) for regeneration and management costs was calculated at the given discount rate of 8% for one rotation (equation (1)), and this total compounded cost was divided by total production to determine average production costs per cubic meter at the given discount rate of 8% (equation (2)):

$$\text{Net Future Value (NFV) of Costs} = \sum_{n=1}^{t} \text{Annual Costs } (1+i)^t \tag{1}$$

$$\text{Total Wood Production Costs @ 8\%} = \text{NFV/total volume} \tag{2}$$

Where: n = year, t = rotation age, i = discount (interest) rate (8%), total volume = total wood volume produced (m^3)

This preceding investment calculation computes the cost of producing wood based on (a) the costs of regeneration and management, and (b) a cost of capital of 8%, which represents the profit for the landowner.

As a second approach, the timber price data also allowed us to compute an average cost per cubic meter at production costs and at the market prices – the price of the stumpage, per equation (3):

$$\text{Total Wood Costs at Stumpage Price} = \left(\sum_{c=1}^{z}(\text{Stumpage Price per Unit} \times \text{Volume per Class})\right) \Big/ \text{Total Volume} \tag{3}$$

Where: c = product class, z = number of product classes, total volume = total wood volume produced (m^3)

This second method of wood cost estimation provided a means to estimate total wood costs simply based on timber stumpage prices, not costs. If the costs of regeneration and management and the cost of capital at 8% exactly equaled the stumpage prices, these wood costs would be the same. Usually, however, the stumpage prices were greater or less than the costs of wood at 8%, so the two means for calculating wood costs would reflect this difference.

2.3. Comparative sustainable forest management regulations

There is little comprehensive literature on comparative environmental regulations in the world. Cashore and McDermott [11] examined the content of forestry regulations from 20 developed and developing countries, ranking forest regulation stringency according to five key measures considered common to forestry regulations and important to the concept of sustainable forest management. These included management of riparian zones, clearcuts, road construction, reforestation, and annual allowable cut. McGinley [12] developed a more extensive approach to assessing sustainable forest management (SFM) among countries based on a "smart regulation" schema by Gunningham et al. [13]. She identified common criteria and indicators (C&I) of SFM to compare the rigor of forestry laws and policies, and then classifying them by degree of regulation – mandatory or voluntary – and by type of approach – process, prescriptive, or outcome based.

We simplified the McGinley schema for this analysis by simply indicating whether a country had a mandatory law for each of the 23 SFM indicators. These indicators covered a broad range of SFM C&I components, including: (1) mandated compliance with national laws, (2) planning, (3) operations, (4) environmental and ecological issues, (5) social issues, and (6) economic/financial issues. Countries that had more laws regarding forestry practices for these issues were considered to have stricter government policies to achieve SFM.

Relevant data for the Brazil, Chile, Argentina, Uruguay, and for Paraguay – and for two diverse states in the U.S. – North Carolina and Oregon – were collected by reviewing their laws on the web and verification with personal contacts in each country. Argentina, Brazil, and the United States have a federal system with both national and state laws, so we chose one or two significant forested states to analyze for those countries. For each indicator, we determined if the combined federal and state laws made a specific requirement regarding the forest management practices, whether there was no relevant legal standard, or if there were standards that applied in some specific cases – such as on streams or steep slopes; for designated tree species; or for public ownerships in particular.

The net effect of stricter or more lax laws on wood costs is moot. Furthermore, the amount of implementation of these laws also may affect their impact on forest management and wood costs. This analysis does not make conclusions about these factors, but does provide more information that at least suggests whether some countries are apt to have fewer legal requirements, which is usually associated with less adverse impacts on wood costs.

2.4. Country risk

The Belgium Export Credit Agency [14] rankings were used to categorize countries for their political risk, commercial risk, war risk, government action or expropriation risk, or transfer risk, on a scale ranging from 1 (very safe) to 7 (very dangerous). We also collected data from the World Bank [15] on the ease of doing business, which ranked all the major countries in the world from 1 to 181 in order for several factors. These data provide measures of business climate and security, which may be more important than potential high rates of return in any particular country. Data on the number of days and procedures to start a business also was examined from an earlier World Bank [16] study.

3. Results

3.1. Timber plantation investment returns

Timber growth and yield, forest establishment and management costs, timber prices, and rotation lengths determined the rates of return for investments in the countries we examined. Establishment costs excluding the price of land among countries varied moderately, averaging about 958 $ ha^{-1}, with a standard deviation of 372 $ ha^{-1}. Establishment costs ranged from about 500 $ ha^{-1} at the least – for *Eucalyptus globulus* in Uruguay, *Gmelina arborea* in Venezuela, *Pinus radiata* pulpwood in Chile – to 1900 $ ha^{-1} for *Eucalyptus* in Colombia. Timber prices varied more by species and country, with stumpage prices for pulpwood varying from about 5 to 20 $ m^{-3} in most cases, very small sawtimber (chip-and-saw) ranging from 25 to 50 $ m^{-3}, and small sawtimber ranging from 22 to 55 $ m^{-3}. Teak (*Tectona grandis*) prices were much greater than this, at up to 220 $ m^{-3} in Venezuela or 900 $ m^{-3} in Indonesia.

Table 1 summarizes results on timber growth rates, rotation lengths, and capital budgeting criteria for the principal plantation species in the southern hemisphere and in the United States and China in 2008. Excluding land costs, exotic plantations in almost all of South America – Brazil, Argentina, Uruguay, Chile, Colombia, Venezuela, and Paraguay – were quite attractive, with an internal rate of return (IRR) of more than 15%. *Eucalyptus* species returns were generally greater than those for *Pinus* species in each country, with most having IRRs of 20% or more, except for in Paraguay and Colombia. *Pinus* species IRRs in South America were generally closer to 15%, except in Argentina, where they were 20%. IRRs were less, but still attractive for plantations of coniferous or deciduous species in China, South Africa, New Zealand, Indonesia, and the United States, ranging from 7% to 12%. Almost all of these IRRs were greater than those found by previously in a similar study [3] for the same species and locations based on costs and prices in 2005, and surely exceeded those of most other asset classes for 2008 and 2009.

The land expectation values (LEVs) varied more than the IRR. NPV and LEV are considered to be the best criteria for capital budgeting at a given discount rate. Using LEV, *eucalyptus spp*. and teak (*T. grandis*) in South America still had the best returns, but with more variation among countries. At the 8% discount rate, Brazil generally had the greatest LEVs, which is an indicator of what one could pay for bare land plus make the computed return equal to or better than the discount rate. *Eucalyptus grandis* sawtimber had an LEV of approximately 8300 $ ha^{-1}; *P. taeda* 5200 $ ha^{-1}; *P. eliottii* 2900 $ ha^{-1} in Brazil. Colombia had the next highest LEVs, at almost 5400 $ ha^{-1} for *eucalyptus* and *P. tecunumanii* and 4100 $ ha^{-1} for *P. maximinoi*. Argentina was next with about 3200 $ ha^{-1} for *P. taeda* and *E. grandis*.

Chile had high LEVs for the best sites and valuable *P. radiata*, at nearly $2800 per ha, but poorer sites with pulpwood had lesser LEVs, at 900 $ ha^{-1}. Venezuela and Paraguay also had quite large LEVs, ranging from 1500 to 4000 $ ha^{-1}, except for teak, at 9800 $ ha^{-1}. Uruguay and South Africa had LEVs ranging from about 1000–3000 $ ha^{-1}. Meanwhile, China, New Zealand, and the two U.S. regions barely met or were less than the 8% internal rate of return for timber investments, without any land costs, so they had small or slightly negative LEVs.

The results indicate that timber investments of exotic species in the South American countries could earn the 8% discount rate, and make excess profits beyond 8%, as indicated by the positive LEVs. Temperate and subtropical countries generally had IRRs close to the 8% discount rate, but did not earn much excess profits, as indicated by the small (or negative) LEVs. The results are somewhat surprising, indicating large potential returns for countries that have not had much external timber plantation investments to date (Colombia, Venezuela, and Paraguay), compared to countries with large plantation areas such as the U.S., Brazil, New Zealand, South Africa, and Uruguay. This suggests that factors such as low risks and good business climates have been more important than theoretically high rates of return in guiding industrial wood plantation investment decisions.

3.2. Wood production costs

Based on our estimates of timber investment returns, we could calculate total wood costs at (1) the discount rate or 8% y^{-1}, and at (2) the market price for stumpage. The cost of wood at the discount rate would be indicative of the price of wood per cubic meter for a vertically integrated forest product firm, where the discount rate would equal its cost of capital, and be reflected as the transfer price, not the market price. The usually higher wood costs at market price would indicate the price of wood at prevailing stumpage prices, either for independent forest land growers or for vertically integrated forest products firms that used market prices as transfer prices. Thus if wood costs at stumpage prices were greater than at the 8% cost of capital, the excess returns would indicate the greater LEVs and IRRs for landowners, and vice versa. Those excess returns are profits in excess of the 8% cost of capital.

There were substantial differences in these two measures of costs of wood per cubic meter for the same species and

Table 1 – Plantation timber stand investment analysis summary for selected species in the world, 2008.

Country	Species	Rotation age	Establishment costs, age 0–5 ($ ha^{-1})	Volume per Ha		Discounted cash flow value ($ ha^{-1} @ 8%)		IRR (%)	Wood costs at rotation ($ per m^3)	
				m^3 ha^{-1} per year	Total harvest (m^3)	NPV	LEV		At cost of capital – 8%	At stumpage price
Argentina	*P. taeda* – Misiones	18	852	30	540	2401	3202	20.0	4.43	20.18
	E. grandis	15	962	35	525	2176	3178	18.2	6.48	24.25
Brazil	*P. taeda*	15	1046	30	450	3590	5242	20.8	8.90	34.21
	P. eliottii	20	856	22	445	2389	2928	16.3	13.67	42.86
	E. grandis sawtimber 2006	15	490	30	450	3427	5004	21.4	8.80	32.96
	E. grandis sawtimber 2008	15	735	40	600	5690	8311	25.5	6.60	36.69
Chile	*P. radiata* sawtimber	22	742	30	660	2270	2782	15.6	10.91	30.91
	P. radiata pulpwood	16	542	20	320	633	894	13.1	7.10	13.88
China	*P. massoniana*	15	771	9.5	142.5	73	92	12.1	23.64	30.92
Colombia	*E. spp.*	19	1887	30	710	4133	5380	16.6	21.64	52.82
	P. tecunumanii	19	1793	31	845	4113	5353	15.5	20.81	51.41
	P. patula	19	1578	19	498	1225	1594	11.2	30.61	45.29
	P. maximinoi	19	1592	25	697	3189	4125	14.7	23.10	51.59
Indonesia	*T. grandis* – government set price	60	735	6	158	−95	−96	7.8	8.22	7.62
	T. grandis – market price	60	735	6	158	1833	1851	11.2	8.22	19.82
New Zealand	*P. radiata*	28	1388	17	480	−204	−230	7.6	36.87	33.20
Paraguay	*P. taeda* Parana basin	20	960	32	1010	1294	1648	12.0	22.45	31.87
	E. grandis	12	1013	38	361	2552	4233	21.4	18.89	32.99
	E. camuldensis	12	1040	28	336	1207	2002	15.4	21.41	30.46
South Africa	*P. patula*	30	820	14	526	1677	1862	11.1	60.36	92.44
	E. grandis	20	1017	32	637	2256	2872	12.4	21.86	38.36
Uruguay	*E. globulus*	9	525	22	198	1178	2358	22.9	6.10	18.00
	E. grandis	16	560	30	240	983	1389	13.9	6.92	13.94
	P. taeda	24	593	20	480	883	1048	12.8	12.85	25.02
USA	*P. taeda* South average	30	953	15	450	151	171	8.5	31.05	34.16
	P. taeda North Carolina	23	1062	12.5	288	−269	−324	6.9	30.48	24.98
	Ps. menzeii Site II	45	1284	14	628	−755	−779	6.5	87.08	48.74
	Ps. menzeii Site I	45	1284	18	1037	−28	−29	8.0	52.98	52.13
Venezuela	*E. spp.*	6	688	25	150	1074	2905	22.4	14.23	20.00
	Gm. arborea	5	468	25	125	459	1439	18.8	12.20	20.00
	P. caribaea	12	735	18	216	1509	2504	15.0	22.40	40.00
	T. grandis	21	951	25	312	7693	9800	21.2	23.69	103.50
Mean			958	23	459	1835	2585	14.9	21.41	36.10
Standard deviation			372	9	241	1834	2439	5.2	17.75	20.26

NPV = Net Present Value; LEV = Land Expectation Value; IRR = Internal Rate of Return.

within a country. This reflects that those species and countries with high productivities and investment returns will have low costs of wood at a given 8% discount rate, but much higher costs of wood at market prices and higher rates of return. This would suggest considerable financial advantage for vertically integrated forest products firms in most of the relevant South American countries and species, which could make a profit on the wood costs based on comparable market prices. It also might suggest that there is a substantial advantage for them to intensify their forest management practices, to achieve greater IRRs and more profits on the transfer price of wood within their own firm.

Conversely, the results suggest that there is little or a negative financial benefit for land ownership for vertically integrated forest products firms in temperate or subtropical forests with rates of return of about 8%, or that have long rotations, where the discount rate has a large adverse impact on costs. In fact, if the rates of return are less than the selected 8% discount rate, such as in most temperate countries, it would be better for forest products companies to buy the cheaper wood from other owners who would bear the loss in profits and LEV below the 8% hurdle rate. This is an interesting finding in itself, perhaps revealing one important financial factor for the widespread shift of U.S. and New Zealand forest land ownership from vertically integrated firms to other forest ownerships, and contributing to a strong financial reason for the prevalence of vertical integration in Latin America.

The mean stumpage wood costs at rotation for all the countries and species analyzed was 23.49 $ m^{-3} at the 8% discount rate, and 36.50 $ m^{-3} at market prices for stumpage. Wood costs at stumpage prices were as much as 83 $ m^{-3}. These averages varied greatly among countries. In addition, they varied by type of product, with pulpwood fiber generally being cheaper to grow than sawtimber. Pulpwood has shorter rotations, with less capital carrying costs for short rotations, and lower stumpage prices, which cause its generally lower wood costs.

At the cost of capital of 8% y^{-1}, Argentina, Uruguay, Brazil, Indonesia, and Chile had the lowest cost of wood per cubic meter, respectively, ranging from 4.43 $ m^{-3} to 12.85 $ m^{-3} at the most, with *eucalyptus* being the lowest cost fiber in most cases. At the relevant stumpage market prices, the order of wood costs per cubic meter changed, ranging from 13.94 $ m^{-3} to 42.86 $ m^{-3}, with Uruguay being cheapest, followed by Argentina, Chile, and Brazil. Indonesia costs were low as well, but for teak, a rare species. Based on the relatively high stumpage prices in Brazil, wood costs per cubic meter increased substantially. This provides excellent profits for investors, and perhaps even vertically integrated forest products firms, but would increase their net total wood production costs per unit.

Countries with wood costs at 8% y^{-1} that were close to the mean included Paraguay, Venezuela, China, and *Eucalyptus* in South Africa, with stumpage wood costs ranging from 12.20 to 23.69 $ m^{-3}. The wood costs at market prices for these countries ranged from 20 to 40 m^{-3}. The stumpage costs at the 8% y^{-1} discount rate were greater for Colombia, New Zealand, South Africa *P. patula*, and the southern and western United States, ranging from 29.74 to 87.08 $ m^{-3}. However, this is where not achieving an 8% discount rate matters the most. In most of these cases, having a slightly lower internal rate of return meant that the cost of stumpage at market prices was actually less. At market prices, stumpage costs ranged from 33.20 to 56.32 $ m^{-3}.

There was a wide range in the estimated costs of wood among countries, with the four major Latin American countries of Argentina, Uruguay, Chile, and Brazil having the cheapest stumpage production in the world at a given 8% discount rate. And in fact, these countries comprise 89% of the total plantation area in South America [17]. As the demand for wood with better markets has increased, stumpage prices have increased, which has increased market wood prices, especially in Brazil.

As noted, higher wood costs existed for sawtimber production compared to pulpwood production, such as in the U.S. and New Zealand. Thus higher costs alone are not only associated with temperate forest plantations, but also with solid wood and structural products, which do have much larger final product prices for lumber, panels, and poles compared to pulpwood fiber. We lacked data on biomass plantations, but one might expect them to have lower wood costs, or at least more similar to pulpwood plantations.

3.3. *Comparative sustainable forest management regulations*

Government regulations have large effects on industrial wood production, and are often cited as factors that provide unfair trade advantages among countries. Table 2 indicates that of the 23 individual indicators analyzed [18], the number of mandatory laws addressing all or selected forest practices ranged from the fewest of 7 in North Carolina, USA to 18 as the most in Chile, Minais Gerais, Brazil, and Misiones, Argentina. Paraguay had 15 laws or standards that were required for all or selected forest lands, followed by Oregon, USA (14), Misiones, Argentina, and Uruguay (11). Chile had the most regulations that applied to all forest lands in the country, and Brazil and Argentina had many regulations to selected lands, such as no harvests in broad riparian zones, steep hillsides, and hill and mountain tops, or separate laws for public lands.

Almost every country basically required compliance with national laws, proof of land tenure, and provided statutory protection from illegal trespass. Most countries and state/provinces except North Carolina required a management plan for harvest. Chile had the strictest planning requirements, including minimum rotation allowed for some species and some monitoring. For forest harvesting operations, North Carolina and Uruguay had the least specific legal requirements, and Oregon, Chile, and Minais Geris, Brazil had the most. Virtually all the countries and regions had laws covering environmental and ecological protection, which at least applied to at risk species, protected sensitive areas, and riparian areas. Only North Carolina did not specifically regulate land use change in some fashion.

Social issues were less regulated than environmental issues everywhere. The four South American countries of Argentina, Brazil, Chile, and Paraguay each had laws addressing indigenous rights. Uruguay lacks indigenous natives and laws, and North Carolina and Oregon address this only through separate treaties that designated lands and rights for Native Americans. Community involvement and public reporting is involved in some cases in the Southern Cone countries, but not in the two U.S. states. Similarly, no locales required financial analyses of forestry investments or had specific wood utilization standards. On the other hand, all locations had various property or income tax reductions for forest landowners and/or manufacturers. Argentina, Chile, and both U.S. states currently have federal and/or state tree-planting incentives for landowners. Uruguay just phased out such direct payments that had existed for almost 20 years [19] and Brazil phased out similar subsidies about 30 years ago. But Uruguay has retained tax advantages for forests planted in designated non-agriculture land use zones.

Overall, the review of laws suggests that the countries and state/provinces differ somewhat, but no more than the differences among the states in the U.S. Chile, Brazil, and

Table 2 – Summary of selected sustainable forest management laws by country and state or province.

Characteristic/country	Argentina/ Misiones	Brazil/Minais Gerais	Chile	Paraguay	Uruguay	United States/ North Carolina	United States/Oregon
Mandated compliance with national laws							
Required compliance with federal law	Y	Y	Y	Y	Y	Y	Y
Proof of land tenure required	Y	Y	Y	S	N	N	N
Protection from illegal trespass/possession	Y	Y	Y	N	Y	Y	Y
Planning							
Inventory methods required	N	N	Y	Y	N	N	N
Management plan required for harvest	Y	Y	Y	Y	Y	N	Y
Annual allowable cut limit	N	N	S	N	N	N	N
Minimum cutting cycle or rotation required	N	N	Y	N	N	N	N
Monitoring required	N	S	Y	N	N	N	N
Operations							
Best management practices	N	Y	N	N	Y		
Required decommissioning of roads	N	N	Y	N	N	N	Y
Clear cut size limits	N	Y	S	Y	N	N	Y
Erosion control rules	Y	S	Y	Y	Y	Y	Y
Regeneration required and silviculture permitted	N	Y	Y	Y	S	N	Y
Environmental/ecological issues							
At risk species protection required	Y	Y	Y	Y	Y	Y	Y
Protected areas limits established	Y	Y	Y	Y	Y	S	S
Land use change regulated	Y	S	S	S	N	N	S
Riparian buffer zone limits established	Y	Y	Y	Y	Y	Y	Y
Social issues							
Indigenous rights established	Y	Y	Y	S	N	N	N
Community involvement required	S	S	N	N	N	N	N
Public reporting required	S	S	N	Y	S	N	N
Economic/financial issues							
Financial analysis required	N	N	N	N	N	N	N
Wood waste minimization required	N	N	N	N	N	N	Y
Incentives/tax benefits for managed forests	Y	Y	Y	Y	Y	Y	Y

Key: Y = Yes; N = No; S = Selected species, areas, or public ownerships.
Source: McGinley et al., 2009 [18]; authors' review of country laws.

Argentina have the most SFM regulations and laws, and Chile has the most regulations that apply to all lands. Brazil and Argentina cover as many forest practices, but some of their laws apply to only part of the forested area (e.g., all hardwood forests in Chile, and the riparian zones, steep slopes, and hill/mountain tops in Brazil). Uruguay and North Carolina have the fewest mandatory requirements, but key environmental and operational controls exist in both locales. Thus it would be hard to make categorical statements that any country eschews regulations or provides subsidies that provide undue competitive advantage. And this is particularly true for the case for forest plantations, where regulations are generally more consistent with sustainable forest management principles.

It is worth noting that these laws are less apt to regulate plantation forestry directly, but instead are mostly designed to protect existing natural forests, essentially adding some unproductive area and buffer zones to plantation management. In the U.S. forestry regulations generally cover planted and natural forests alike. Brazil requires substantial reserves of natural forests as part of the plantation forest landscape. In all countries in the Southern Cone, if one complies with natural forest and buffer reserve requirements, direct regulation of plantation management is moderate.

3.4. *Political and economic risk*

3.4.1. *Export transactions and direst investments*

The Belgium Export Credit Agency [14] provides a clear rating of countries for their political risk related to export transactions and for direct investment, on a scale ranging from 1 (very safe) to 7 (very dangerous). Six criteria for risk are summarized in Table 3 for each country in the study, as well as three other major forestry countries for reference – Canada, Russia, and Finland.

For export transactions as of 2009, the short term political risk in each country was small to medium, with developed countries in the northern hemisphere having the least risk with a rating of 1, and Argentina and Venezuela having the greatest, with rating of 4. Long term political risk, which is

Table 3 – Country risk ratings for selected countries, 2009.

	Export transactions			Direct investments		
	Political risk short term	Political risk medium/long term	Commercial risk	War risk	Risk of expropriation/ government action	Transfer risk
Argentina	4	7	C	3	4	6
Brazil	2	3	C	2	2	3
Canada	1	1	B	1	1	1
Chile	2	2	A	1	1	2
China	1	2	C	2	4	2
Colombia	2	4	C	5	3	4
Finland	1	1	A	1	1	1
Indonesia	2	5	C	2	5	3
New Zealand	1	1	B	1	1	1
Paraguay	3	5	C	3	4	5
Russia	2	3	C	3	4	3
South Africa	3	3	C	2	2	3
United States	1	1	B	1	1	1
Uruguay	3	4	B	2	2	4
Venezuela	4	6	C	4	7	5

Definitions: *Commercial risk*: Risk resulting from the deterioration of the debtor's financial situation, leading to the impossibility to pay the debt.
Expropriation: Includes all forms of nationalisation of the local enterprise, including creeping expropriation. This can arise from various measures taken by public authorities, taken simultaneously or otherwise, whose accumulation denotes a confiscatory nature.
Government action: These are local authorities' decisions, deficiencies and impairments that are of an arbitrary and discriminatory nature. Notion used to describe the credit period usually associated with current trade transactions.
Transfer risk: Risk resulting from an event or decision by foreign authorities that prevents the transfer of the amount of the debt paid by the debtor.
Political risk: Any event occurring abroad which assumes the nature of force majeure for the insured or for the debtor, such as in particular, wars, revolutions, natural disasters, currency shortages, government action.
Source: ONDD [14].

important for forestry investments, was generally greater for each non-northern developed country except Chile, which had a low rating of 2. Argentina (7) and Venezuela (6) had the greatest political risks, perhaps due to fears of more export bans or selective timber and agricultural export taxes, which did occur in Argentina in 2008 through 2010. Chile and Finland had the best commercial risk ratings of all countries selected, with an A grade. The United States, New Zealand, Canada, and Uruguay had a commercial risk rating of B, and the remaining countries had a C rating.

For direct investments, war risk was rated highest in Colombia (5) and Venezuela (4). Venezuela was the most risky for risk of expropriation and government action (7), and in fact expropriated 1500 ha of forest industry land in March, 2009. Venezuela was followed by Indonesia (5), and Argentina, Paraguay, and Russia (4). The United States, Chile, New Zealand, and Finland had the least risk of expropriation (1), and South Africa and Brazil had a rank 2. The transfer risk was greatest in Argentina, Venezuela, and Paraguay.

3.4.2. *Ease of doing business*

Table 4 summarizes World Bank [15] ratings of the ease of doing business in the same countries as presented in Table 3. Out of 181 countries, New Zealand was ranked as the second best country in the world in terms of ease of doing business (Singapore was first), and the United States was ranked third. South Africa (32), Chile (40), and Colombia (53) also are ranked highly, followed by China (83) in the selected forest plantation countries. Conversely, Venezuela (174), Indonesia (129), and Brazil (125) are among the lower half of the ranked countries in the world.

Starting a business is ranked as very difficult in Indonesia, China, Venezuela, Argentina, and perhaps Brazil. Registering property was actually better in most countries, although Uruguay, Brazil, and Indonesia were in the bottom half of the rankings. Venezuela was ranked the worst at protecting investors, and most of the developing countries except Chile were ranked as difficult in terms of paying many taxes. Trading across borders was easier in developed countries, and ranked as difficult in most developing countries. Enforcing contracts was ranked best in the United States and New Zealand and worst in Colombia and Indonesia. A little known problem with businesses is the ability to close them legally, which was ranked as very hard in Venezuela, Indonesia, and Brazil, and best in the developed countries. Brazil also took the most actions and the most days to start a business of all the countries in the Americas [16].

Experience indicates that these deceivingly neutral rankings imply a large amount of difficulty in the countries that have large numbers. Ranks above 100 generally imply considerable difficulty and expense and time in their category, and ranks in the upper quartile of 135 or more infer large difficulties and perhaps high risks of failure to perform the desired business activity. Conversely, ranks in the lower quartile of less than 45 indicate countries and business activities with relative security and confidence that can be performed at minimum effort and cost. While many of the developed countries, as well as New Zealand and South Africa,

Table 4 – Ease of doing business for selected countries, 2009.

Economy	Ease of doing business rank	Starting a business	Registering property	Protecting investors	Paying taxes	Trading across borders	Enforcing contracts	Closing a business
Argentina	113	135	95	104	134	106	73	83
Brazil	125	127	111	70	145	92	100	127
Canada	8	2	32	5	28	44	58	4
Chile	40	55	39	38	41	53	65	112
China	83	151	30	88	132	48	18	62
Colombia	53	79	78	24	141	96	149	30
Finland	14	18	21	53	97	4	5	5
Indonesia	129	171	107	53	116	37	140	139
New Zealand	2	1	3	1	12	23	11	17
Paraguay	115	82	70	53	102	138	103	116
Russia	120	65	49	88	134	161	18	89
South Africa	32	47	87	9	23	147	82	73
United States	3	6	12	5	46	15	6	15
Uruguay	109	120	149	88	167	127	99	44
Venezuela	174	142	92	170	177	164	71	149

Total number of countries = 181.
Source: [15].

timber investment returns are less and wood costs more, the costs of doing business may make net returns much closer, and the exposure to risk of loss much less.

4. Discussion

The results of this research help explain current distribution of industrial timber investments and comparative advantages among countries. They also help identify opportunities for expansion of timberland investments, and a means to assess prospects for extension of industrial wood production to woody biomass energy production, where the methods, costs, and comparative advantages are likely to be similar.

4.1. *Country comparisons*

The results indicate that based on large biological productivities, reasonable input costs, good timber prices, and strong timber and product markets, Brazil usually maintains comparative financial advantages in growing timber, at least without considering land costs, taxes, and other business investment factors. Three other Latin American countries have expanded timber production capacity substantially in the last four decades, including Chile, Argentina, and Uruguay, in that order of timber plantation area. In fact, since 1960, South America has increased its share from 3% to 10% of the world industrial wood production [20]. The rates of return are high and wood production costs at transfer prices can be comparatively low for vertically integrated forest products firms; domestic markets have increased moderately; and production is often close to export markets while infrastructure is improving. Carle and Holmgren [1] also concluded that South America and Asia have the most promise for increased plantation area in their analysis of future plantation scenarios.

However, Brazil and Chile have substantial environmental rules and regulations affecting forest operations, and substantial enforcement agencies, albeit not always consistent implementation. Furthermore, Brazil is ranked as the hardest country in the Americas to start a business in terms of number of days and number of procedures [16], and has a challenging system of business, environmental, tax, and other laws, which require high transaction costs and close attention to details.

For example, Leal [21] noted that the type of legal vehicle – real estate fund, investment fund, or company/corporation – determined the best tax treatments in Brazil, with the best system depending on the size of the investment. Brazil has a dual tax regime for corporations; the effective tax rate depends not only on profits but also on revenues; and the stability of tax law depends on the organizational model; which in turn affects whether it is better to sell stumpage or delivered wood. The effective tax rate may vary between as little as 5% to at least 34% depending on how an investment deal is structured, with possible taxes on sale of products, value added taxes, and municipal taxes, so the tax regime and legal set up should be defined for each investment.

Leal [21] also noted that social responsibility is a passport to success in Brazil. Local community support is an enabler of regulatory licenses, helping prevent problems, accelerate licenses, and reducing possibility of theft, strike, and labor claims. The poorer the region, the more important social responsibility becomes to the return on investment. Similarly, Daniels and Caulfield [22] stressed the advantages of forest certification for timberland investors in Latin America. In the countries where the laws or the enforcement are weak, certification provides investors certainty that their timberlands are managed to high standards. Forest certification does have costs, but can provide access to international financing and bank loans for developing countries. And in some cases, wood can be sold only if it is certified.

Chile and perhaps Uruguay seem to have more stable, efficient, and transparent business laws, particularly for foreign investors. Argentina has excellent land and growth rates and moderate environmental laws, but has a populist government that defaulted on the national debt in 2001;

instituted prohibitive taxes on exports of agricultural products in 2008; forbade timber exports to Uruguay from Entre Rios province; and banned beef exports in 2010, which have contributed to a higher political risk rating. On the other hand, Argentina has some of the most competitive free markets for timber in Latin America, with hundreds of small sawmills and many small landowners in its Northeastern wood basket provinces of Misiones and Corrientes. Chile has less available land for new forest investments, and has some of the strictest forest laws in Latin America. Uruguay has land purchase opportunities, but they are becoming scarcer and land prices have increased considerably.

Smaller countries such as Colombia, Paraguay, and Venezuela all seem to have potentially attractive financial returns, and their opportunities will be defined mostly by political and safety considerations. The ascension of Hugo Chavez and unlimited term limits in Venezuela will deter most external and even internal investors. Paraguay could attract more foreign direct investment if the government builds confidence, minimizes corruption, and improves its road infrastructure. And Colombia appears quite attractive if the government can continue to maintain and enhance security of investments and investors in the country. Higher political risk factors in these countries must decrease to attract foreign direct investment, but Colombia at least also has some internal capacity to generate capital.

In the more developed countries in other parts of the Southern Hemisphere – South Africa and New Zealand, and perhaps Australia – the rates of timber investment returns are moderate, and delivered industrial wood costs should be slightly greater than in South America, but still attractive. New Zealand had the second best business climate in the world, which has attracted a large amount of capital to their forest sector. Each country does have moderate environmental regulations, and a large amount of certified forests as a share of the area. Their continued political and economic stability will keep current investors, and perhaps attract some new investments, although land may be expensive.

Temperate timber plantation investments on existing forest land, such as in the United States and China, achieve about a 8% real internal rate of return, which still looks quite attractive compared to other assets and investments as of early 2009. These lower timber investment returns would still translate into greater delivered wood costs than in South America, and somewhat less profits in forest manufacturing. The U.S. business climate is still considered among the best in the world, and China's is ranked highly. Our review indicates that forestry regulations in the U.S. South are less stringent than other major South American plantation countries, while the West Coast has among the strictest. These results agree with the findings from Cashore and McDermott [11] as well, who ranked the U.S. South as having the least strict regulatory environment of 20 locations in the world based on the five forest practices examined.

4.2. *Sensitivity analysis, wood costs, industry structure, and biomass*

The results provide new insights about planted timber investment returns for a wide range of major countries in the world. They are limited by reasonable assumptions, most notably not including land or taxes as factor costs. Land prices were considered too variable to model, and good price data are lacking. Taxes are important, but harder to specify and obtain. At the very least, land costs would reduce the high internal rates of return and land expectation values, unless it appreciated at rates greater than the IRR or discount rate, respectively. Cubbage et al. [3] performed some sensitivity on land prices and environmental regulations on a similar 2005 data set, and found that they did tend to reduce returns in Brazil most, and in Uruguay and the U.S. the least, making net returns closer. On the other hand, increases in factor costs or stumpage prices also could change returns, with Brazil and Chile having the most "upside" potential. In fact, returns in Brazil in this study increased the most since 2005 based on higher stumpage prices in 2008.

Wood cost calculations generally found that Latin America countries had lower wood costs at the 8% discount rate; costs of wood at stumpage prices were much greater than at the 8% cost of capital; and pulpwood production costs were much less than solid wood costs. The implications of high investment returns versus low wood costs at the 8% discount rate also have novel financial and investment implications. This gap between potentially high returns and low wood costs at a reasonable cost of capital would favor integrated forest products firms as a means to capture this large profit margin. It might help explain why vertically integrated forest products firms prevail in Latin America. Other investors also can profit from good investment returns, but the integrated firm advantage is relatively unique, and also would encourage high management intensities to increase this profit opportunity. The flip side of this is that for temperate forests with reasonable rates of return or less than the discount rate, forest products firms would be better served to let other owners grow the wood, and could actually buy it cheaper than they could produce it. And intensive silviculture might not help redress this difference, or at least is not likely to help much.

Differences in wood grades and products also probably affected the results. Sawtimber products generally had higher investment returns (and wood costs), and pulpwood products generally had lower returns (and the least wood costs) for each country. Southern Cone countries usually had the best investment returns and least wood costs, and *eucalyptus* species were usually better than *pinus* species. We did not assess wood grade and quality, but U.S. southern pine still has advantages by being denser and graded for structural use. *Eucalyptus* production focused initially on pulpwood fiber, but has expanded more into solid wood products.

5. Conclusions

An ideal financial investment would have high investment rates of return, low costs of wood for industrial uses, modest environmental regulations, low risk, and a good business climate. At least the first two of these criteria are mutually incompatible, and achieving high returns with less risk and more security is elusive at best. So the relative advantages of each country combine some quantitative and some subjective standards that investors must weigh in making decisions.

This research and the discussion examined these factors, and indicated that there are substantial differences in pre-tax timber investment returns among countries, as well as the rigor of their forestry laws and their business climate. Tropical and subtropical countries in South America and Indonesia that grow plantations of exotic species usually had faster growth rates and higher plantation investment returns, with IRRs of 12% or more. Most of these, however, had worse political, trade, and business risk rankings, as well as at least as many forestry regulations. Temperate countries such as in the United States, New Zealand, South Africa, and China had quite acceptable returns, at about 8% IRR, and better ranked business climates, and perhaps less regulations on paper than tropical countries.

The market structure and infrastructure among different countries also will influence timber investment returns greatly. The U.S. has relatively competitive open markets for stumpage, and has only a few major vertically integrated forest product firms with more than 0.5 million ha of land remaining. Many sawmills still do own some timberlands, but in smaller holdings. Major pulp manufacturers now rely almost completely on market wood, although they often do have long term timber purchase agreements. Thus U.S. stumpage and delivered prices reflect reasonable interaction among supply and demand from many competitors. Conversely, in Latin America, New Zealand, and South Africa, almost all of the plantations were initially planted just to provide wood for integrated timberlands and manufacturing facilities, at a minimum cost. The open markets have developed slowly afterwards and are often still quite thin. Open market stumpage or delivered to mill prices reflect probably only 25% or so on most areas in Latin America and Indonesia, so the stated prices are less reliable, except for Argentina, which has very competitive markets.

Infrastructure also varies substantially among developed and less developed countries. Most plantations in the temperate forests have established roads and infrastructure and relatively uniform markets. New plantations in developing countries will often have to build new roads and infrastructure, and develop new market outlets, which will decrease returns from those calculated here. Taxes, corruption, and stable and favorable domestic policies remain important. Thus good locations for plantations, careful business arrangements, and perhaps some optimism, are required for an investor to actually achieve the high rates of return found here in some countries. This situation may change as more investors buy and plant timberland in these countries, such as Uruguay and Argentina, but still requires some faith that good markets and associated public policies will exist in the future at time of harvest.

The implications of our results for more plantation investments, especially for biomass, also are interesting. The results help explain why secure investments with seemingly moderate rates of return remain attractive, such as in the U.S., New Zealand, and South Africa. Simply put, low risk and good business climate appear to be the foundation for attracting long term investments for large plantation areas in these established plantation countries. They suggest that the same can be true for developing countries, as has occurred in the four major Southern Cone countries to some extent, and is in process in China. Achieving such stability will be the key for other countries to attract foreign and domestic capital.

The implications may be importantly different for biomass plantations, however. If tree-planting costs and stumpage prices are about the same as we assumed, biomass production should be equally profitable and wood production costs relatively low, like pulpwood fiber. However, biomass and biofuels are more likely to be locally consumed and processed. And investment funds also may be more from the local country, or at perhaps from extra-national governments and nongovernment organizations. Biomass prices have been cheap in the past, but if they receive stumpage prices more similar to pulpwood, or even high cost petroleum or electric energy prices, these investments could be quite attractive, and less dependent on foreign direct investment. These factors will still take some time to play out as the world economic conditions evolve, but offer considerable promise for plantations as a means to produce fuel wood as well as industrial wood in the near future.

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