International Trade and Forest Conservation Leakage

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Abstract

Forest conservation in one country is likely to lead to less conservation or more deforestation in other countries because of unbalanced conservation policies across countries and the international linkages of the forest products industry and markets. This paper describes an analytical framework for measuring the transnational leakage of forest conservation and provides empirical estimates of such leakage via applied general equilibrium modeling. The simulation results reveal that a significant portion (43%-96%) of the reduced forestry production resulting from forest conservation in various countries/regions would be transferred to elsewhere. This implies that forest conservation efforts made by individual countries/regions could seriously be undermined if without effective international cooperation to alleviate the transnational leakage.

Keywords: Global forest conservation, forest product trade, log export restriction, applied general equilibrium.

I. Introduction

Forest conservation in one place may lead to less conservation or more deforestation elsewhere (Sohngen, Mendelsohn, and Sedjo 1999; Sedjo 1995). This phenomenon is often referred to as "leakage" such as in the context of carbon sequestration (IPCC 2001). Such leakage can significantly undermine the net gain in global forest conservation obtained from a conservation effort initiated by an individual country (Mayer et al. 2005; Berlik, Kittredge, and Foster 2002). While leakage associated with forest conservation has been recognized, few studies have attempted to empirically measure it, particularly at the global level and in the framework of international trade. This paper describes an analytical framework for measuring the transnational leakage associated with forest conservation and provides empirical estimates of such leakage. The empirical results will offer insights into the efficacy of unilateral forest conservation efforts and policy implications for more effective global forest conservation.

Forest conservation leakage could be due to a variety of reasons including imbalance of conservation programs and forest conditions across countries/regions, features of conservation programs, and market factors such as trade, among others (Murray, McCarl, and Lee 2004). For instance, recently adopted forest certification programs are a market-driven means to promote sustainable forest management. Forest certification is not mandatory; several certification systems with different standards coexist (Cashore, Auld, and Newsom 2004). Because of the regional imbalance of forest conditions and the voluntary nature of the program, forest certification may not necessarily curb tropical deforestation (Gan 2005) as the program was initially intended. The interrelationship between timber trade and the environment is complex, though timber trade may not directly cause deforestation (Barbier et al. 1994). Trade has been criticized for contributing to environmental degradation in some cases, but in some other circumstances it may complement environmental protection directly or indirectly (WTO 2004).

A handful of literature has addressed the leakage issue associated with forestry projects or programs. Most of the existing studies in this area focus primarily on the leakage of forest carbon sequestration programs. Murray, McCarl, and Lee (2004) probe the interactions of market forces that affect carbon leakage and identify the key parameters that determine the leakage. They develop procedures for leakage estimation and empirically estimate the leakage from forest carbon sequestration programs in the U.S. using both econometric and sector-optimization models. Their estimated leakage rates vary with the program and region with a range from less than 10% to over 90%, suggesting the importance and need for accounting for leakage in carbon sequestration policy design and analysis. Chomitz (2002) assesses and compares carbon leakage from land use change and forestry (LUCF) and energy projects. He finds that there is no systematical difference in the likelihood of leakage between LUCF projects and energy projects, instead the magnitude of leakage is dependent on how the project is integrated with a broader physical and economic system. Using a global timber market model, Sedjo and Sohngen (2000) evaluate the potential leakage of global forest carbon sequestration from the establishment of large-scale carbon plantations. Their study reveals that the leakage from the carbon plantations would be modest (<16%, or only 0.2~7.8 million ha of commercial timber plantations would be crowded out by 50 million ha hypothetical carbon plantations). Alig et al. (1997) examine the role of forests in carbon sequestration in the U.S. using a multiregional and multisectoral model. Their results indicate that carbon benefits attained from afforestation in the U.S. would be considerably offset, primarily by conversion of forestlands to agricultural uses. Other related literature include the synthesis of the results from studies on the leakage issue (Schwarze, Niles, and Olander 2002) and qualitative analysis of leakage potential and the value of leakage reductions (Aukland, Costa, and Brown 2003; Geres and Michaelowa 2002).

Several studies also have directly or indirectly explored the leakage of other forest conservation programs. Wear and Murray (2004) analyze the effect of forest conservation on the public lands in the U.S. Pacific Northwest and the resultant interactions among the regional forest products markets in the U.S. Their study offers useful information for understanding the potential leakage associated with the federal conservation effort (timber harvest reductions to protect endangered species). About 43% of the reduced timber harvest on the public lands would leak out to private timberlands within the region, 58% to private and other public timberlands within the U.S., and 84% to North America (the U.S. and Canada) (Murray, McCarl, and Lee 2004). Findings from other studies, which though are not directly intended for qualifying leakage, are also indicative of such potential. Lee, Kaiser, and Alig (1992) investigate whether federal cost-sharing programs for tree planting on private lands have discouraged investments in tree planting by non-industrial private forestland owners in the U.S. Their study suggests that there is no strong evidence for such linkage, implying that the counter-effect between the federal programs and private investments in tree planting is minimal. Wu (2000) examines the potential slippage of the Conservation Reserve Program (CRP) and reports that on average about 20% of the acreage enrolled in the CRP is offset by expansion of cropland cultivated elsewhere.

In general, existing estimation of forest conservation leakage is mostly at the local or regional level. This paper expands existing literature by estimating the transnational leakage of forest conservation programs at the global level. The leakage is analyzed in the framework of international trade using a computable general equilibrium (CGE) model. This approach allows for the consideration of interregional and intersectoral interactions induced by forest conservation and international trade.

The rest of the paper is organized as follows. I will begin with describing an analytical framework and procedure for estimating the leakage using a simple two-country model. Then, the empirical estimation method involving CGE modeling will be explained. Finally, results will be presented, followed by a summary and discussion on policy implications for global forest conservation.

II. Theoretical Framework

A change in timber production in one country (especially a large country) is likely to induce output reactions by other countries due to market linkages. Forest conservation in one country often would reduce timber harvest in that country. Because of the interactions of global markets, part of the reduced timber production in that country would be offset by increased production elsewhere, causing leakage of the conservation effort. In this study, forest conservation leakage (L) is defined as dQ/dq, where dq is the reduced timber harvest in the country that adopts a conservation program and dQ is the resultant net change in total timber production in all other countries.

For the reason of tractability, I will start with a two-country model to develop an analytical framework for leakage assessment, and then extend it to more complex cases involving more than two countries. Figure 1 depicts the two-country case. Without loss of generosity, assume that country I has an excess demand for forestry products, whereas country II has an excess supply of forestry products. The world price (P^o_w) is determined by equaling the excess demand to the excess supply. Now suppose that country II implements a forest conservation program (e.g., adopting higher forest management standards) that will lead to an increase in its forestry production cost. As a result, the supply curve in country II will shift upwards from S_{II} to S'_{II}. Correspondently, the excess supply curve will shift upwards from ES to ES′. With the demand unchanged, the world price will go up from P^{o}_{w} to P'_{w}, and the volume of trade between the two countries will decline from q^{o}_{w} to q'_{w}. Consequently, the production in country II will reduce from q^{o}_{II} to q'_{II}, whereas the production in country I will increase from q^{o}_{I} to q'_{I}. Thus, the net change in the world production will be $(q'_{I} - q^{o}_{I}) + (q'_{II} - q^{o}_{II})$. The reduction in the world output will be smaller than the production reduction attained in country II $(q^{o}_{II} - q'_{II})$, implying that part of the conservation effort made by country II would leak because of the increased production in country I. The leakage (L) can be measured by the following ratio:

$$L = \frac{q_I^{'} - q_I^{o}}{q_{II}^{o} - q_{II}^{'}}. \qquad (1)$$

Thus, the net conservation gain for the two countries as a whole will be equal to $(1 - L)(q^{o}_{II} - q'_{II})$.

When more than two countries are involved, the situation becomes much more complicated. Ideally, one should consider using a multiregional general equilibrium model to examine the case (to be further discussed later). To help understand the leakage issue associated with this case, an intuitive illustration is presented in Figure 2. Suppose that a country imports its forestry products from country A and all other countries, aggregately called “the rest of the world.” Its total supply (S_T) of forestry products consists of domestic supply (S_d) and imports from country A (S_a) and the rest of the world (S_r). For the ease of graphic presentation, assume that the importing country is relatively large so that it has some influence on the world market. That is, its import supply curves are not perfectly elastic.

Suppose that country A adopts a forest conservation program, leading to the shift of S_a to S'_a. This will result in the shift of the total supply for the importing country from S_T to S'_T. Given the demand curve, the market price in the country will go up from P^o to P'. As a result, the quantity of imports from country A will decline from q^o_a to q'_a, indicating the gross impact of adopting the conservation program in country A (for simplicity, assume that all forestry production in country A is exported to the importing country). However, in response to the increased price, the importing country will increase its domestic production from q^o_d to q'_d and imports from the rest of the world from q^o_r to q'_r. The import reduction from country A will be partially offset by the increased domestic production and imports from other countries. This suggests the transnational leakage of the conservation effort made by country A. The magnitude of the leakage can be measured by[1]

$$L = \frac{(q_d^{'} - q_d^{o}) + (q_r^{'} - q_r^{o})}{q_a^{o} - q_a^{'}}. \tag{2}$$

In this case the global net conservation outcome is $(1 - L)(q^o_a - q'_a)$.

III. Empirical Estimation

When many countries and sectors are involved, the complexity of multiregional and multisectoral linkages makes it logical to apply computable general equilibrium modeling in estimating the transnational leakage. The Global Trade Analysis Project (GTAP) model (Hertel 1997) was employed in this analysis. Version 6 of the GTAP database was used, which contained the data for 57 sectors (commodity groups) and 87 countries/regions with a base year

[1] The impact on the domestic demand in country A, its exports to the rest of the world, and production and trade in the rest of the world is not considered here due to the limitation of graphical presentation. More general impacts in the case of multiple regions will be described in the next section.

of 2001. This model makes it possible to take into account the interactions among different regions and sectors, which is extremely important for leakage assessment.

The original GTAP model is a comparative static model. It portrays the behavior of economic agents such as regional households (private households and governments) and firms under the assumptions of market equilibrium and perfect competition. The regional households generate incomes from land, labor, capital, natural resources, and taxes. The total regional income is allocated to private household consumption, government consumption, and savings based on a Cobb-Douglas per capita utility function. The profit-maximizing firms use primary factors and intermediate inputs to produce final goods and services under a nested constant elasticity of substitution (CES) production structure, which implies constant returns to scale production technology. Products are differentiated by country of origin using the Armington (1969) structure. The private households, firms, and governments in different regions interact with one another through trade.

Global transportation costs are also considered in the model. Transportation service is compensated with the difference between the f.o.b. (free on board) and c.i.f. (cost, insurance, and freight) values. Investment goods are allocated to all firms and households according to savings and rates of return on capital by a hypothetical global bank. The structure and behavioral equations of the GTAP model can be found in Hertel (1997).

In this study the original countries/regions in the standard GTAP model were further aggregated into 10 countries/regions: the United States of America (USA), Canada (CAN), the European Union (EU, including only the formerly 15 EU countries), Australasia (ANZ, including Australia and New Zealand), East Asia (EAS), Southeast Asia (SEA), Latin America (LAM), the Russia Federation (RUS), Sub-Saharan Africa (SSA), and the rest of the world

(ROW, including all the remaining regions/countries in the GTAP database). These regions were aggregated according to their importance in the world's production, consumption, and trade of forest products; current forest conditions and management practices; economic development status; and geographic location. Each regional economy was divided into 10 sectors: forestry (FOR), lumber and wood products (LUM), pulp and paper (PPR), agriculture and food (AGF), agriculture-based fiber (FBR), plastic products (PLS), metal products (MTL), mining and energy (MNG), manufacturing (MNF), and services (SVS). The sector aggregation reflects the emphasis of this study on forestry and related sectors and allows for examining the interactions among closely related sectors such as FOR, LUM, PPR, AGF, and FBR. More detailed descriptions of these sectors and regions are presented in Table 1.

The responses to an output change in a specific region (r) by other regions were simulated by directly shocking the forestry output of the region, qo(FOR, r). To meet the model closure requirement, qo(FOR, r) was swapped with the output tax, to(FOR, r). This approach has its merit. Forest conservation and environmental protection (e.g., adopting higher forest management standards) in an individual country would lead to an increase in its forestry production cost. Making the output tax endogenous allows for mimicking cost changes as the output is altered.

In addition to forest conservation and protection programs, log export restrictions/bans have been widely used by many timber producing countries to protect their domestic wood processing industry and/or the environment (Lane 1998; Barbier et al. 1994). Table 2 shows that except for a few countries/regions, only a small portion of forestry products (primarily logs) are traded internationally although their import tariffs are very modest in general. Largely due to log export restrictions/bans, only some 7% of the world forestry output is exported, which is also similar to the percent of industrial roundwood traded internationally (FAO 2006). On the contrary, processed wood products are actively traded globally. Approximately one-third of the world production of sawnwood, wood-based panels, or paper and paper boards enters the international trade (FAO 2006). Because of the linkage between logs and processed wood products, it would be interesting to know how log export restriction policies have affected global forest conservation. Thus, another simulation scenario mimicking log export restrictions was also experimented. In this scenario, the shocking variable was the export tax/subsidy of forestry products in a specific country/region.

IV. Results

(a) Leakage from Output Reduction

Table 2 shows the transnational leakage derived from the GTAP model simulation. The leakage was measured with the net output change in all other regions due to a unitary reduction in forestry production in a specific country/region. Of all the countries/regions modeled, Russia has the highest leakage rate (96%), whereas Canada has the lowest (43%). Most of the reduced timber production in Russia would be displaced by increased production in East Asia (28%[2]), the EU (21%), and the rest of the world (12%). This mirrors the fact that most of Russian timber exports currently go to East Asia and the EU. Almost all the countries/regions (except for Canada and the rest of the world) have a leakage rate of greater than 70%. This suggests that the global net gain from forest conservation in an individual country is quite modest, in general less than 30%. Among all the countries/regions, forest conservation (in terms of timber production reduction) in Canada is likely to generate the highest net gain for the world.

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[2] The percent inside parentheses in this section indicates the leakage rate. For instance, here it means that 28 percent of the reduced production in Russia would be offset by East Asia.

Probably more disturbing is that a significant portion of the reduced forestry production in developed countries would be transferred to developing countries where forest conservation is even more critically needed. Seventy-six percent of the reduced timber harvest in the EU, 70% in Australia and New Zealand, and 47% in the U.S. would be transferred to developing countries, mainly tropical forest regions. The majority of reduced timber production in the EU would be offset by increased production in the rest of the world (30%), Southeast Asia (16%), and Russia (10%). The main countries/regions that would displace timber production in Australia and New Zealand would be East Asia (36%), Southeast Asia (12%), and the U.S. (10%). East Asia (20%) and Canada (20%) would displace most of the reduced timber production in the U.S. The high leakage rates call into question the effectiveness of forest conservation implemented by individual countries if without international cooperation to alleviate such leaching.

(b) Leakage from Log Export Restrictions

Trade, on the one hand, has been blamed for harming forest conservation. On the other hand, some trade restriction policy could also fuel forest conservation leakage. Table 3 presents the leakage rates resulting from log export restrictions imposed by individual countries/regions. Except for East Asia (the world's largest net importer of logs), the estimated leakage rate for all other countries/regions is higher than that derived from a direct output reduction (Table 2). Surprisingly, for many countries/regions the total leakage rate is even greater than one, implying that more timber would be harvested worldwide than the reduced production in the country that adopts the log export restriction. The greater-than-one leakage rate might be due to several reasons. First, log export restrictions would lower the domestic timber price, boosting domestic demand for wood products. Thus, more timber would be harvested to meet the domestic demand under the log export restriction than without the restriction. Second, the log export restriction, as the policy is intended in many cases, would stimulate the development of the domestic wood processing industry, which may not as efficient as the same industry in some other countries in terms of the utilization of logs. Third, the log export restriction would encourage timber production in some other countries where the efficiency of wood processing might be lower than in the country that imposes the export restriction. Fourth, though the limit is imposed on log exports, it does not restrain international trade of processed wood products. Thus, the total world demand for wood products might not decline.

The highest leakage caused by log export restrictions would occur in Southeast Asia, followed by Sub-Sahara Africa and Latin America. This suggests that tropical log export restrictions would significantly boost timber harvest elsewhere. Similarly, log export restrictions in developed countries would also induce high leakage of forestry production to developing countries. Eighty-five percent of the reduced timber production in the EU due to the log export restriction, 70% in the U.S., 62% in Australia and New Zealand, and 52% in Canada would be transferred to developing countries. Therefore, log export restrictions, while adding values to the domestic economy and keep jobs within the country, generally encourage global timber production, thus harming global forest conservation.

V. Concluding Remarks

This study develops a procedure for estimating the transnational leakage of forest conservation using a simple two-country model and empirically estimates the leakage via CGE modeling. Under the current global trade conditions and system, the estimated leakage rate ranges from 42% for Canada to 96% for Russia with a leakage rate of 70% or higher for most countries/regions. Hence, the gain from forest conservation efforts made by an individual country could tremendously be undermined if without a mechanism to prevent transnational leakage. In addition, a sizable portion of the reduced timber production in developed countries/regions such as the EU, Australia, New Zealand, and the U.S. would be transferred to developing countries, mainly tropical timber producing countries. It was estimated that 76% of the logging reduction in the EU, 70% in Australia and New Zealand, and 47% in the U.S. would be displaced by increased harvesting in developing countries, suggesting that the net gain from forest conservation in these developed countries would be very modest.

Though the leakage may be partly due to international trade of forest products, which makes it possible for forest products to flow from one country to another, some trade restriction policy such as log export restrictions or bans would not alleviate, but exaggerate such leakage. The high leakage rate resulting unintentionally from the log export restriction/ban might be attributed to several factors including the increased domestic demand for logs as the export restriction may lower the domestic log price, inefficiency in log utilization due to the trade distortion, and little impact of the export restriction on the world's demand for processed wood products. Compared with other countries/regions, tropical timber producing countries/regions have the highest leakage rate resulting from their log export restrictions.

These findings have several implications for global forest resource conservation. First, because of the high leakage rates, the contribution of conservation efforts in one country to global forest conservation is very limited. Therefore, there is an urgent need for global cooperation and joint efforts in forest conservation. Second, reducing timber production in developed countries would not be very effective to enhance forest conservation at the global aggregate level because a large percent of the reduced forestry production would be transferred to developing countries where forest resources in general are managed in a less sustainable manner. Therefore, policy to encourage forestry production in developed countries or discourage the transfer of wood processing capacity to developing countries might do more good than harm to global forest conservation. Finally, log export restrictions/bans should be discouraged from the perspective of global forest conservation. Though the log export restriction policies adopted by some countries are not originally intended for forest conservation, these policies have unexpected effects on global forest conservation. Log export restrictions would not only cause inefficiency in resource allocation (Tumaneng-Diete, Ferguson, and MacLaren 2005; Manurung and Buongiorno 1997; Perez-Garcia, Lippke, and Baker 1997) and uncertain impacts on domestic forest conservation (Richards 1995), but also lead to the high transnational leakage of forest conservation. Coupled with illegal logging (Hewitt 2005; Brack 2003), log export restrictions might unintentionally counteract global forest conservation.

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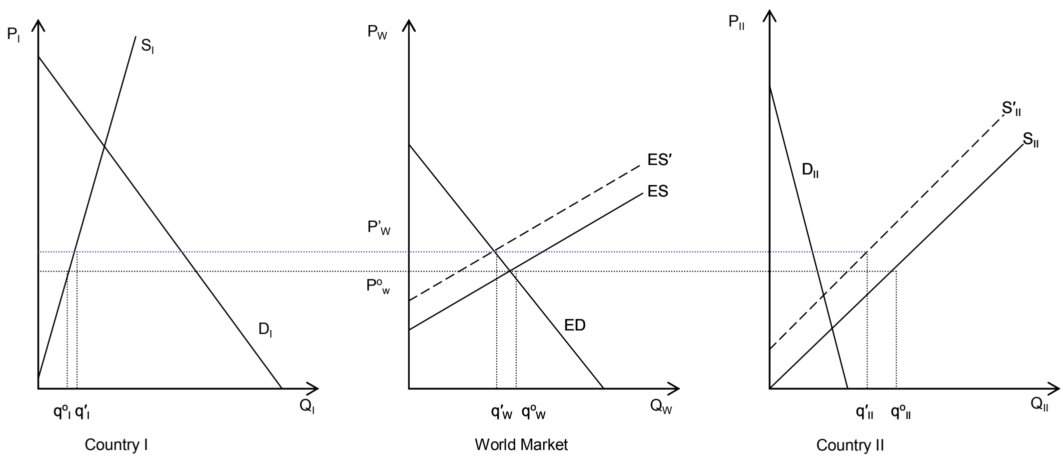

Figure 1. Forest conservation leakage in the two-country case.

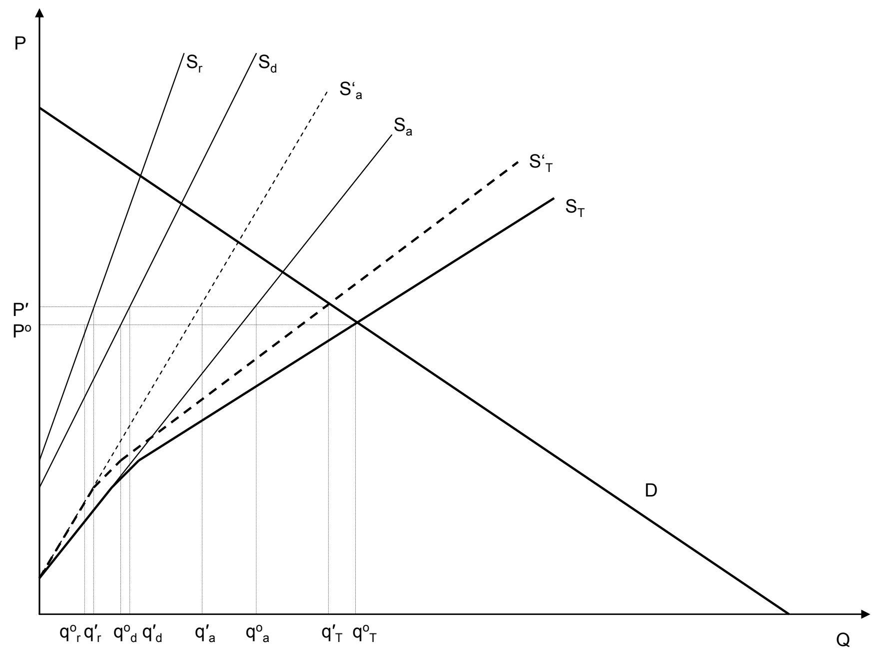

Figure 2. Forest conservation leakage in the case of more than two countries.

Table 1. Regional and sectoral aggregation.

Regional Identifier	Country/Region	Sectoral Identifier	Sector
USA	The United States of America	FOR	Forestry
CAN	Canada	LUM	Lumber and wood products
EU	The European Union (including only the former 15 EU countries)	PPR	Pulp, paper, and allied products
ANZ	Australasia (Australia and New Zealand)	AGF	Agriculture and food processing
EAS	East Asia including Japan, China, Hong Kong, Taiwan, Korea, and Singapore	FBR	Plant-based fiber, wool, silk-worm cocoons
SEA	Southeast Asia	PLS	Chemical, rubber, and plastic products
LAM	Latin America	MTL	Ferrous metals, metal necessities, and metal products
SSA	Sub-Saharan Africa	MNG	Mining and primary energy
RUS	The Russia Federation	MNF	Manufacturing
ROW	The rest of the world (all the remaining countries in the GTAP database)	SVS	Services

Table 2. Shares of forestry output traded and import tariffs by region.

Region/Country	Percent of output exported	Percent of imports in total consumption	Import tariffs (%)
The United States of America	7.04	2.02	0.03
Canada	3.32	3.65	0.00
The European Union (EU15)	8.39	18.01	0.03
Australasia	30.98	0.95	0.61
East Asia	0.57	14.41	0.43
Southeast Asia	17.63	4.38	0.66
Latin America	3.12	1.26	4.16
Sub-Saharan Africa	12.73	0.47	2.98
The Russia Federation	47.69	1.48	4.69
The rest of the world	4.44	5.55	5.07
The world total	7.45	8.11	0.89

Data source: GTAP v6.

Table 3. Transnational leakage in forestry production.

Region/Country	Leakage to outside of the U.S., EU, Canada, and Australasia	Total leakage
The United States of America	0.47	0.78
Canada	0.21	0.43
The European Union (EU15)	0.76	0.88
Australasia	0.70	0.89
East Asia	0.37	0.71
Southeast Asia	0.51	0.77
Latin America	0.35	0.76
Sub-Saharan Africa	0.51	0.89
The Russia Federation	0.59	0.96
The rest of the world	0.32	0.67

Note: The leakage is measured with the total net change in forestry output in all other countries/regions due to a unitary change in forestry output in a country/region.

Table 4. Transnational leakage in forestry production due to log export restrictions imposed by individual countries.

Region/Country	Leakage to outside of the U.S., EU, Canada, and Australasia	Total leakage
The United States of America	0.70	1.04
Canada	0.52	1.04
The European Union (EU15)	0.85	1.02
Australasia	0.62	0.84
East Asia	0.21	0.26
Southeast Asia	1.06	1.43
Latin America	0.50	1.08
Sub-Saharan Africa	0.71	1.22
The Russia Federation	0.63	1.03
The rest of the world	0.38	1.01

Note: The leakage is measured with the ratio of the total net change in forestry output in all other countries/regions to the change in forestry output resulting from imposing the log export restriction in a country/region.