

## I. INTRODUCTION

This paper reviews forestry reform in the Congo basin, focusing on Gabon, and analyzes the choice of tax base in the forestry sector, which is still an unsettled debate. Unlike forests in Latin America and Asia, in the Congo basin the risks of excessive logging are lower because commercial species represent just a small proportion of the forest stock—no more than two or three trees per hectare can be logged for commercial use.<sup>1</sup> The main risk to the forests comes from its destruction for agricultural uses, subsistence consumption of wood, and extensive opening of roads, which entails more destruction of the forests and allows poachers access to more areas.

With nowadays overwhelming evidence of the increasing risks of climate change, preserving tropical forests is of paramount importance.<sup>2</sup> In this regard, countries with abundance of forests are generating positive externalities if they maintain their resources intact. However, for doing so, the countries must be compensated for the foregone of both revenues and economic activity. Unless a mechanism to compensate these countries is in place, where beneficiaries of the externalities transfer equivalent resources, owners of forestry resources would continue exploiting their resources. Perhaps, an intermediate solution in the context of the bidding for concessions is that beneficiaries should also participate and bid to obtain concessions that would further be used as natural areas. The topic of how to compensate countries for maintaining their forest intact deserves a rigorous analysis and should be the subject of a different paper.

The key challenge for the Congo basin countries in this domain is to manage their forests in a sustainable manner while obtaining a fair share for their exploitation. The current proposal is that the Congo basin adopts a generalized area tax through a bidding process for allocating concessions with the bidding parameter being the amount of tax to be paid. The rationale is that the area tax strengthens sustainable management by confining logging to areas that can be efficiently exploited. This proposal has been heavily criticized by foresters.

From regional experiences, foresters do not favor competitive bidding because they see the lack of information and inadequate infrastructure as impediments to an appropriate bidding process. More than a year is needed to make an inventory of the area and it is costly. In several cases companies have found that the forest density in the concessions assigned was below the expected profitability threshold.

This paper works from the proposition that tax policy should be used exclusively for revenue purposes and resource preservation should be achieved mainly through legislation and enforcement.<sup>3</sup> Given the particular situation of the Congo basin forests, where the likelihood

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<sup>1</sup> Of some 300 species of trees in Gabon's forests, no more than 20 are commercially valuable.

<sup>2</sup> The Stern's report on the Economics of Climate Change widely elaborate on the serious global risks of climate change.

<sup>3</sup> Several papers show that fiscal instruments do not substitute for traditional regulation and could end undermining sustainability. See, for instance, Leruth, Paris, and Ruzicka (2001).

of resource depletion is not as high as in other regions, using a static model of optimal taxation it concludes that when prices are uncertain the best practice is to tax only profits; therefore, it advocates elimination in the medium term of export, and stumpage taxes and reinforcement of a unique profit tax. Though the Congo basin countries may not yet have the administrative capacity to implement a profit tax, it could be a medium-term goal. Moreover, since some Congo basin countries, notably Gabon, are already increasing domestic transformation and reducing log exports, it would be well to advance the reform in the direction of a tax base that could capture that scenario.

Though controversial, the choice of a static model better captures the situation of Gabon and the Congo basin. Applying a dynamic model, for instance the traditional Faustmann model to taxation,<sup>4</sup> is not deemed appropriate because it mainly focuses on finding an optimal rotation period for felling trees. Neither is the traditional problem of overexploitation suffered by Asian and Latin American forests present in the Congo basin. A static model could provide more insight for a decision about the tax base and could perform better in analyzing the risk behavior of foresters.

## **II. REFORM AND TAXATION IN THE CONGO BASIN: THE CURRENT SITUATION**

The general objectives of forestry sector reform in the Congo Basin are to

- make the management of forest resources sustainable;<sup>5</sup>
- improve the business and investment climate;
- introduce a tax system that is simple, transparent, and equitable; and
- ensure an equitable sharing of forestry rents among private entrepreneurs, the central government, and local communities.

Forestry taxation should ensure that forest rents are shared equitably among stakeholders. It should also make investment attractive by ensuring equal opportunities and fair competition among private operators. Appropriate taxes combined with auctions can shape incentives toward higher forest yield by increasing harvesting per hectare and reducing timber waste.

With sustainable management in Gabon and most other Congo basin countries, which is still far from being applied, the forestry sector could be an element to promote development on a sustainable basis. Given increasing demand from international markets for both logs and processed products from the region, evolution of the sector should be guided with a view to protect the resource and it should focus on the following issues:

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<sup>4</sup> In the Faustmann model an optimal rotation for tree-felling is established to maximize the net present value of after-tax income.

<sup>5</sup> Taking into account the need to protect resources for the long term and thus contribute to address the global problem of climate change.

**Source of fiscal revenues.** Currently, forestry produces only a relatively minor proportion of tax revenues. This may be because tax systems are poorly designed, compliance is minimal, or governance is weak—or for all these reasons. With better designed systems, firmer tax administration, and less corruption, revenues from the forest sector could be raised substantially. Lately, some countries in the region are adopting the area tax with concessions allocated through public auction.

**Export earnings.** In some Congo basin countries, forestry is becoming the second largest export after oil. In Asian and European markets demand is rising for tropical logs, of which there is abundance in the region.

**Labor markets.** A considerable proportion of the labor force is already employed in the labor-intensive forestry sector, and another large proportion depends on forests for subsistence. With proper incentives, forests could become leading employers not only in logging and processing but also in forest management and tourism.

**Domestic activity.** There is potential for a substantial processing industry generating additional value added. With this in mind, most of the regional governments are limiting the export of logs and taxing those exported at higher rates. This preferential treatment is aimed at expanding processing industries.

The private sector can bolster activity in the sector through job creation, remitting revenue to governments at all levels, and directly contributing to rural development in remote areas. However, the current institutional and regulatory situation places obstacles in the way of these private sector contributions.

Foreign investment is critical for sustainable development in Africa. In the last few years foreign companies have been investing not only in forest exploitation but also increasingly in processing. However, investment in Africa does not compare favorably with investment in Eastern Europe, Asia, and Latin America, because of (i) long distance to points of shipment and a lack of public roads; (ii) high transport and harbor costs and a long delivery time for imported spare parts; (iii) high costs for workforce training; (iv) the need for costly private power generation in most locations; (v) banking sector reluctance to provide long-term finance for forest industry investments; (vi) an investment climate that does not promote the stability of long-term investments; (vii) governments that do not respect their commitments; and (viii) lack of equity between formal companies and their informal competitors that do not pay taxes and are not interested in sustainable forest management.<sup>6</sup>

### III. THE GLOBAL AND REGIONAL SITUATION

Forest products, both primary and processed,<sup>7</sup> account for about 3 percent of the world's GDP. The main exporters and importers are G7 countries, though the importance of some

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<sup>6</sup> These concerns were expressed by industry representatives in a meeting in Washington with the World Bank and the Fund on January 15, 2004.

<sup>7</sup> Primary products are logs, sawn wood, panels, and pulp. Processed products are paper, furniture, and doors, among others. Paper and related products constitute about half the value of forest products.

developing countries—China, Indonesia, Malaysia, Thailand, Mexico, Russia, and Taiwan Province of China especially—is increasing.

While Africa's share of the general world market for forest products is less than 5 percent, in the market for tropical timber,<sup>8</sup> its share in 2001 was about 20 percent of the world exports, led by the production and export of roundwood (logs) and sawn wood (23 percent of the market), of which Cameroon is a world leading exporter. China, the world's largest importer of tropical logs, is a key market for Africa's exports. According to the International Tropical Timber Organization (ITTO), in 2001 China took in about 45 percent of total imports of tropical logs.

In 2002 Africa's share in the tropical timber market represented 11 percent of total production and 10 percent of total processed exports. Owing to its low level of transformation, 32 percent of felled logs were exported, compared with 12 percent in the Asia-Pacific region, and less than 1 percent in Latin America. The amount of transformation has increased lately, partly because of export restrictions and government fostering of value added in the sector.

Table 1: Total Exports of Tropical Timber<sup>9</sup> (US\$ million)

	2000	2001
<b>Africa*</b>	1,469	1,501
Cameroon	433	318
CAR	56	101
DRC	21	21
Congo	101	155
Ivory Coast	191	188
Gabon	315	348
Ghana	137	139
Liberia	214	228
Togo	1	1
<b>Asia-Pacific</b>	6,117	5,332
<b>Latin America/Caribbean</b>	672	573
<b>Total</b>	8,260	7,406

\* Excluding Equatorial Guinea, which is a non-ITTO member

Source: ITTO

Forests, which cover a substantial part of the region, are vital to the economy of the Congo basin through commercial exploitation, subsistence, and tourism. While the Democratic Republic of Congo contains the largest area of unspoiled forests, Gabon and Congo, where population density is low, have the largest number of hectares of forest per capita.

<sup>8</sup> The chief countries trading in tropical timber are Indonesia, Brazil, Malaysia, India, and Thailand.

<sup>9</sup> Exports include logs, sawn wood, veneer, and plywood.

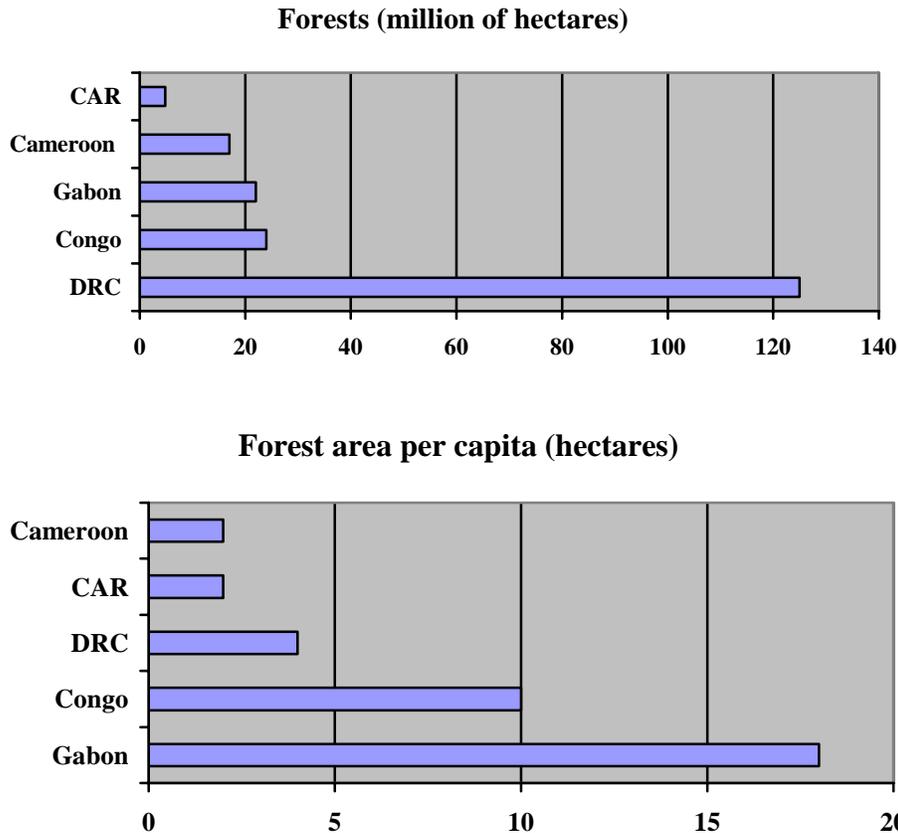


Figure 1. Congo Basin Forestry Statistics.

Sources: Authorities, World Bank estimates, and Wilks (2003).

Despite its importance in economic activity even in the oil-exporting economies, tax revenues from forestry are low. Though most of the countries are moving to adopt management plans and new tax regulations, governance problems and lack of enforcement are slowing the sustainable development of the sector and governments are not collecting their due share. Conservative estimates of revenue losses in 2003 for the Congo basin region (World Bank/ WWF, 2003) could be as much as US\$25 million annually.<sup>10</sup>

Forest taxes in the region yield over US\$150 million of government revenues annually. The main taxes are (1) area taxes, with rates varying from CFAF 250 per hectare (ha) in the Democratic Republic of Congo (DRC) to CFAF 4,100/ha in Cameroon; (2) stumpage taxes from about 1.25 percent in the DRC to 4.5 percent in the Central African Republic (CAR); and (3) export tax on logs from 2 percent in the Republic of Congo (Congo) to 17 and 17.5

<sup>10</sup> Estimates by country are: Cameroon US\$5.3 million, Central African Republic US\$3.0 million, Congo US\$4.2 million, Democratic Republic of Congo US\$2.2 million, and Gabon US\$10.1 million.

percent in Cameroon and Gabon. The DRC taxes exports of transformed products at 8 percent and the CAR at 4.5 percent. All the countries are promoting domestic processing. In Congo, the DRC, and the CAR the law establishes that 60 percent of logs ought to be transformed domestically. Cameroon has a total ban on unprocessed exports of some varieties. Although Gabon does not have such a legal restriction, its forestry code states that by 2012 75 percent of logs must be processed domestically.

Table 2: Forestry Sector Indicators for Selected Central African Countries in 2001

	Fiscal revenues (Percent of GDP)	Valued Added (Percent of GDP)	Land Area (million of hectares)
Cameroon	0.4	7.0	22
Central African Republic	0.9	8.1	5
Congo	0.2	1.5	25
DRC	0.6	1.0	125
Gabon	0.9	2.8	24

Source: Authorities and IMF estimates.

In all countries there is a strong case for strategic reforms over time, such as (1) shifting the burden of taxation away from dependence on export taxes; (2) reducing the number of taxable species; and (3) moving from stumpage and an export taxes to taxation based on the area or on profits.

Currently the priority is the recovery of arrears. Poor recovery is associated with inadequacies in accounting procedures. Only after the substantial improvement of administrative and accounting procedures the reform can take place.

#### IV. THE SITUATION OF GABON

After several years of almost unregulated exploitation of its forest, Gabon in 2001 initiated comprehensive reforms directed toward sustainable management of its forestry resources. Three important measures were implemented that defined the institutional and legal frameworks and the vision of reform and guaranteed the protection and sustainable use of the forests: (i) in 2001 a new Forestry Code was approved. The objectives of the Code are to place forests under sustainable management plans,<sup>11</sup> establish a taxation system that will stimulate sustainable management of the forests, and consolidate a local processing industry; (ii) in 2002 Gabon created a system of 13 national parks. The parks occupy 3 million hectares—about 10.6 percent of the country's area; and (iii) in 2004 Gabon approved a letter

<sup>11</sup> A management plan is a planning program for an area that has a horizon of at least 20 years. It sets a pace of felling to keep the resource sustainable and incorporates an inventory of the stock, a zoning map defining principal roads and areas for annual felling, the duration of the rotation, and a list of the exploitation units.

of development of the forestry sector. The letter, prepared in consultation with the World Bank, lays out an agenda for reform and specifies measures to remove obstacles to reaching the objectives of sustainable management.

### **A. Current challenges**

Though the objectives of the reform have been formulated and Gabon has made substantial progress in only few years, substantial challenges need to be addressed to move the reforms forward.

#### **Forestry taxation**

Taxation of forests in recent years has represented less than 1 percent of GDP and only about 7 percent of total tax revenues.<sup>12</sup> Until recently, the taxation system was cumbersome: at least 20 different taxes and fees burdened sector activities, particularly exports. Moreover, a timber marketing board (SNBG) had the monopoly of the exports of Okoumé and Ozigo and charged a fee on exports to finance its operations. After lengthy negotiations between the government and forestry companies, in 2004 a reform reduced the taxes to three:

**An area tax based on the size of the concession.** Previously rates on this tax differed by zone: Zone A: FCFA 20 per hectare; Zone B: FCFA 12; Zone C: FCFA 8; and Zone D: FCFA 4. The new tax is based only on the size of the concession; the rate is FCFA 600 per hectare. This tax exempts the special and family permits. A temporary provision allows concessions under sustainable management plans to reduce the tax obligation by 50 percent.

**A stumpage tax based on the value of the log.** The rate varies from 2.6 percent to 7.7 according to where the tree is located to reflect costs associated with difficulties in exploitation. The incentive is to reduce waste and to facilitate valuation of the real cost of the activity. The tax exempts special permits and the family exploitation, and differentiates between logs for exports (the tax base is calculated after subtracting 15 percent of the price of the log) and for domestic processing (the tax base is calculated after subtracting 60 percent of the price of the log).

**An export tax of 17 percent on logs:** the rate was lowered from the 2002 level of 20 percent. Processed exports are exempted.

By regional comparisons, the yield of Gabon's forestry taxation is lower. In Cameroon, which produces only about 65 percent as much forestry products as Gabon, forestry taxes in 2003 brought about CFAF 40 billion, compared to CFAF 33 billion for Gabon. Before going to other rounds of tax design, it is crucial to consolidate revenues from this reform by strengthening control mechanisms and collecting tax arrears.

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<sup>12</sup> Forestry tax arrears during 2004-07 are about CFAF 10.7 billion for the area tax and 7.4 billion for the stumpage tax. The government is taking measures to accelerate the rate of recovery of tax arrears, among them introducing retention rates.

It is not feasible in the short run to substitute the stumpage and area taxes for the export tax. A gradual phasing out of the export tax on logs has been recommended because the tax distorts incentives, penalizing exports in favor of domestic processing. However, the stumpage tax is still far of its original target of about CFAF 7 to 8 billion annually, and even farther from full replacement of the export tax, which has an expected yield of about CFAF 25 billions annually over 2003-06. Exemptions from the stumpage tax also introduce distortions that make it difficult to consolidate it and phase out the export tax. For instance, even if the same base is applied to both taxes, the revenues are different because (i) the rate of the export tax is 17 percent and the rate of the stumpage tax varies from 3 percent to 9; (ii) the stumpage tax does not apply to family permits, and special permits are excused, but the export tax does; and (iii) the export tax is applied to the full value of the log but the stumpage tax exempts 15 percent if the log is exported, and 60 percent if it is processed domestically.

Table 3: Gabon. Forestry Sector Tax Revenues. (In billions of FCFA).

	2003	2004	2005	2006
Export Taxes	29.9	22.2	23.5	24.7
Okoumé	15.5	10.0	10.1	9.6
Ozigo	0.3	0.2	0.4	0.6
Other woods	14.1	12.0	13.7	14.9
Stumpage Taxes	2.6	3.6	5.2	4.1
Area Taxes	0.8	4.3	3.7	4.2
Other Taxes	0.6	0.4	...	...
Total	33.9	30.5	32.4	33.0
In percent of total revenues	3.2	2.7	2.3	2.1
In percent of total nonoil tax revenues	7.8	6.7	6.9	6.4
In percent of GDP	1.0	0.8	0.7	0.7

Source: Gabon authorities and staff estimates.

## **Sustainable management and concessions**

The new Forestry Code differentiates forests by rural and permanent domain. The rural domain comprises community and other forests for use by municipalities. Community forests can be commercially exploited. Though the law establishes simplified mandatory management plans for them, in practice it has not been enforced, and a preferential treatment has been granted, exempting certain permit holders from paying stumpage and other taxes.

The permanent domain of the state comprises all the areas that are subject to mandatory management plans. Though the forestry code established the end of 2005 as a deadline for adopting management plans, as of today less than 50 percent of the permanent domain is under forestry management plans.<sup>13</sup> The areas subject to management plan are protected areas including recreational areas,<sup>14</sup> where no exploitation is allowed, and the productive areas where most of the logging takes place. There are three types of productive areas:

Big forestry concessions under sustainable management (Concession forestière sous aménagement durable, CFAD). The size of concessions range from 50,000 to 200,000 hectares; no owner may hold more than 600,000 hectares. These concessions are also associated with processing units. The concession may be granted to foreign investors as long as they submit a management plan.

Medium-size concessions or associated forestry permits (Permis forestier associé, PFA), which are granted exclusively to nationals. A PFA must be associated to a CFAD; the maximum area of 15,000 ha can be extended to 50,000 ha if a management plan is submitted.

Good faith permits (gré a gré), which are granted only to nationals and are managed by the government. The area is measured in feet rather than hectares. Owners of these permits must sell their production domestically to a processing industry.

The main problem has been the appropriate allocation of the permits. When the letter of development policy was being prepared the World Bank advocated (i) a moratorium in the allocation of the gré a gré permits until a transparent mechanism is in place (the moratorium was decreed on October 9, 2004); (ii) making public information about the holders of the permits (since February 2005 they have been listed on the web page of the Ministry of Economy and Finance); (iii) a system of auction to grant concessions, which the government has not yet implemented. The Gabonese looked into the Cameroon's experience to assess how the auction system is being handled.

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<sup>13</sup> Only the big companies, which are mainly foreign-owned, have adopted management plans. These include, Compagnie Equatoriale de Gabon (CEB) Thanry, SBL, Rougier Gabon, Leroy Gabon, and SHM

<sup>14</sup> Includes the system of 13 national parks.

### **The timber marketing board**

The government decided in December 2004 to eliminate the monopoly of the timber marketing board (SNBG)<sup>15</sup> in commercializing Okoumé and Ozigo. The decree established a period of transition in which the SNBG will downsize its operations and transform itself into an institution with functions of surveillance and control of the forestry sector. Because the decision abolished fees amounting to about 10 percent of the sale prices that were borne by the private sector, forestry activity were to increase. Companies are not compelled to export anymore through the SNBG. The SNBG did not downsize its operations and has become an active actor in the domestic trading and exporting of timber, which is contrary to the spirit of the law.

### **The bias toward domestic processing**

As the Forestry Code states, the government aims to process 75 percent of total production domestically by 2012. This is not a new idea: over the years Gabon has planned to build a domestic processing industry. However, when the Forestry Code was approved, the government not only restated that intention, it also offered fiscal incentives for processing. Those incentives include exemption from the stumpage tax of 60 percent of the price of the log, full exemption of the export tax, devolution of the value-added tax paid on inputs for processed exports, and a requirement that certain permits for forestry production be associated with domestic processing units.

The new requirements have indeed increased domestic processing, but have also generated at least three costs: (i) a revenue loss for the government; (ii) a bias against the export of logs; and (iii) efficiency losses in the economy because some new enterprises could not be competitive.<sup>16</sup>

## **B. A Reform Agenda**

A reform agenda in the forestry sector would be based on the following pillars:

**Protection and sustainable exploitation of Gabon's forests.** To accomplish that it will be necessary, first, to consolidate the system of national parks and other protected areas and, second, to enforce the adoption of sustainable management plans in both the productive and the rural domains. The necessary law for consolidation has still to be approved. The law will protect biodiversity and define new protected areas. A new deadline must be given to those permit holders who did not submit plans by the December 2005 and permits should be put on hold if holders fail to comply.

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<sup>15</sup> The government had 51 percent participation and the rest was owned by several producers.

<sup>16</sup> As a side indicator that there were competitiveness problems in the processing industry is that at the end of 2004 most of the nonperforming loans of commercial banks were originated in credits to wood transformation industries.

**Improved taxation.** The reform initiated in 2004 should be further advanced in order to remove distortions and increase tax revenues. The first stage should concentrate on the recovery of area and stumpage tax arrears and enforcement of payment of the stumpage tax particularly from logs used in domestic processing, but the second stage should be directed to phasing out the export tax and strengthening other sources of revenue. As it will be presented in the next section, a long-term objective, provided that the administrative capacity is in place, is to move to a profit tax. The stumpage tax should also be strengthened by eliminating exemptions for exports (15 percent) and domestic processing (60 percent); unifying the rate at a higher level, eliminating exemptions for permits in the rural domain; and making tax administration more efficient. Revenues from forestry taxes might well increase from the current proportion of about 6.4 percent of total non-oil tax revenues to at least 15 percent.

**New permits should be allocated by auction.** As proved in other countries, competitive bidding is the easiest way method to determine the proper rents. The current system of permit allocation lacks transparency. A system based on auctions would make information about the process public and guarantee that new permit holders adopt management plans.

**The government should avoid picking winners and losers in the forestry sector.** Distortions as incentives to domestic processing should be avoided. The sector should compete the way other sectors in the economy do. The sector should be built up in terms of the general objective of diversifying the economy. Measures to benefit the sector are those that reduce transaction costs, as by eliminating the monopoly of the transport syndicate or surcharges like the 1.5 percent fee customs charges for accounting services. Fiscal incentives should be assessed in terms of their incentive to attract investment throughout the economy, such as accelerated depreciation under the corporate income tax.

**It is also important to guarantee that the transformed SNBG, whose control functions will be much more limited, be considerably downsized.** The reformed SNBG should not be a cost to the private sector. It should be publicly funded and devoted to reinforce activities of the ministries of forestry, taxes, and customs.

## V. A MODEL TO ANALYZE OPTIMAL TAXATION

The theory of forestry taxation has been focused mainly on the dynamic aspect of the problem, to wit, the effect of taxation on the firm's decisions to harvest a growing resource. This paper abstracts from that, arguing that optimal regulation (effectively quantity controls, embodied in forestry agreements) will govern harvest rate (as well as any externalities) and instead focuses on the effects of price uncertainty in a static context.

In this section we present a model to analyze what types of taxation would be optimal. The government has three tools for taxing the forestry sector: a tax on the quantity of logs felled or exported, a tax on profits of foresters, and an area tax. Optimal harvesting is being controlled by regulations, so that taxation has the sole role of capturing some share of the resource rents. First let us consider a production function with known concavity properties, with land in fixed supply:

$$Q = F(L, T)$$

Where

Q: Logs

L: Labor

T: Land

Foresters maximize their utility based on profits. Utility is assumed to be concave and continuous in profits. When production shows decreasing returns to scale, foresters are getting pure profits, which under each taxation schedule are the following:

$$\Pi_e = P(1-\tau_e)Q - wL - mT \quad \text{exports}^{17}$$

$$\Pi_p = (1-\tau_p)(PQ - wL - mT) \quad \text{profit}^{18}$$

$$\Pi_t = PQ - wL - (m + \tau_t)T \quad \text{area}$$

Where:

$\Pi$ : Profits.

P: Price

w: Wages

m: Rent

$\tau$ : Tax

There are two groups in this model, foresters (f) and workers (w). Taxes collected by the government are not compensated. Foresters are risk-averse. Utility from both groups is assumed to have a first derivative greater than zero and a negative second derivative with respect to income. A social welfare function can be defined as<sup>19</sup>

$$SW = \Psi U_f + (1 - \Psi) U_w$$

Government revenues depending on the tax system are:

$$R_e = \tau_e PQ \quad \text{from export tax}$$

$$R_p = \tau_p (PQ - wL - mT) \quad \text{from profit tax}$$

$$R_t = \tau_t T \quad \text{from area tax}$$

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<sup>17</sup> In the analysis export and stumpage taxes are treated the same because they are based on the same quantity of logs.

<sup>18</sup> Profit and area taxes are both lump sum taxes; neither distorts labor decisions.

<sup>19</sup> Taxes are assumed to be uncompensated and government to be risk-neutral.

**Proposition 1:** *Assuming a static model with price certainty, profit and area taxes, being both lump sum taxes, dominate over export taxes, which are distortionary and yield less social welfare than other policies. Area and profit taxes are lump sum taxes that do not distort input demand decisions.*

### Introducing price uncertainty

With price uncertainty the willingness of growers and the government to take risks changes results. We first analyze the impact of price uncertainty on input demands.<sup>20</sup> Because growers maximize the expected utility from profits, price is a non-degenerate random variable with a mean  $\mu \rightarrow E(P) = \mu$ .

The only type of uncertainty considered is with regard to output price. Other types of uncertainty, which could be important (eg, with regard to the value of the resource on a given piece of land; production costs; and others) are not considered.

**Proposition 2:** *Labor demand when prices are uncertain is smaller than when they are certain.*

Proof:

Solving the maximization problem for the export tax:

$$E\{ U'(\Pi_e) (P(1-\tau_e)F_L - w) \} = 0$$

$$E\{ U'(\Pi_e) (P(1-\tau_e)F_L) \} = E\{ U'(\Pi_e)w \}$$

Subtracting  $E\{ U'(\Pi_e) (1-\tau_e) \mu F_L \}$  from both sides of the equation

$$E\{ U'(\Pi_e)((P - \mu)(1-\tau_e) F_L) \} = E\{ U'(\Pi_e)(w - \mu(1-\tau_e) F_L) \}$$

Profits for export taxation are defined as

$$\Pi_e = P(1-\tau_e)Q - wL - mT$$

and expectations depend on this expression

$$E(\Pi_e) = \mu(1-\tau_e) Q - wL - mT$$

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<sup>20</sup> Using a model like that of Sandmo (1971), it appears that increasing the rate at which profits are taxed will increase output if relative risk aversion is increasing.

Then

$$\Pi_e = E(\Pi_e) + (P - \mu)(1 - \tau_e) Q$$

Because of the concavity of the utility function, if  $P \geq \mu$ , then

$$U' \{E(\Pi_e)((P - \mu)(1 - \tau_e) F_L)\} \geq U' (\Pi_e)((P - \mu)(1 - \tau_e) F_L)$$

This inequality also holds if  $P < \mu$  because multiplication for a negative number on both sides reverses the inequality. Now expectations of that expression yield:

$$U'(E(\Pi_e))E((P - \mu)(1 - \tau_e) F_L) \geq E\{U'(\Pi_e)(P - \mu)(1 - \tau_e) F_L\}$$

Because the left side becomes 0:

$$0 \geq E\{U'(\Pi_e)(P - \mu)(1 - \tau_e) F_L\}$$

it has also be true that

$$0 \geq E\{U'(\Pi_e)\} (w - \mu(1 - \tau_e) F_L)$$

Because the utility is concave,  $U'(\Pi)$ , is always positive; therefore,

$$w \leq \mu(1 - \tau_e) F_L$$

For the assumed fixed wage, this implies that labor has to decline even more when prices are uncertain because the expected marginal revenue of the input is exceeding its marginal cost. Output and labor are lower with uncertainty. The situation is similar for profit and area taxes: the marginal revenue of the input exceeds its marginal cost. For profits and area it can be proven that

$$w \leq \mu F_L$$

Q.E.D

### **How price uncertainty affects the choice of the optimal tax base**

Foresters and the government take decisions when prices are uncertain. Foresters are assumed to be risk averse, though their behavior shows decreasing absolute risk aversion. The gains from more secure profits indeed change the choice of the tax base. Though utility increases with profits, strictly speaking marginal utility decrease as profits increase. The marginal gains in utility from changes in income are greater when profits are low.

Agents make decisions before the real price is known. Assuming that prices follow an uniform distribution along the range

$$\{P_{\min}, P_{\max}\} \text{ and } E(p) = \mu$$

the distribution is justified on two grounds: first, timber prices appear to have been fluctuating through a range and there is no tendency to a mean price; and second, the use of a uniform distribution facilitates the analysis. The government can use any of the taxes. Expected social welfare comprises a continuum of possibilities attached to a probability, which is the same with the assumption of uniform distribution.

$$E(SW) = c \int_{P_{\min}}^{P_{\max}} U_g(P) + U_w$$

### *1- Using only one tax*

To evaluate expected revenue the government selects a revenue target, then chooses tax rates according to the revenue target, which then makes it possible to compare the yields from the three tax schedules.

#### Export taxation

$$R^* = E(R)$$

$$R^* = \tau_e \mu Q$$

The government assumes that the price is the expected value. Once the tax rate has been chosen, the amount of output is independent of the government.<sup>21</sup> The expected profit to be evaluated in the social welfare function is

$$\Pi_e = P(1-\tau_e)Q - wL - mT$$

After substituting the tax rate, the equation becomes

$$\Pi = (1 - R^*/\mu Q_e)PQ_e - wL - mT$$

#### Profit taxation

$$R^* = \tau_p(\mu Q - wL - mT)$$

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<sup>21</sup> To get the optimal tax rate, an equation of higher order is solved because production is also a function of the tax.



$$2h(\mu Q - wL - mT) - 2h R^*$$

For area taxation:

$$\int PQ_t - wL - (m + R^*/T)T dP$$

$$2h(\mu Q - wL - mT) - 2h R^*$$

Note that while profit and area taxes yield the same result, export taxation decreases expected profit because  $L_e < L$  as  $L$  is the optimal level and any reduction will lower profits.

Foresters are more risk-averse over the interval  $(P_{\min}, \mu)$ , assigning more utility to not having low profits from low prices than to having high profits from favorable prices. The marginal utility of income increases until it reaches  $\mu$ . This makes a difference in the choice of tax base: for the same expected profits, a tax that enables foresters to have higher income over the range  $(P_{\min}, \mu)$  would be preferred over other taxes with the same expected profit.

**Proposition 4:** *Profit taxation is the most efficient way to raise revenues given the assumptions of the risk aversion of foresters and uncertain prices.*

Proof:

Export taxation is the most distortionary tax. The effect of the labor distortion on both foresters and workers income makes the expected social welfare lower than area or profit taxation. Both profit and area taxes yield the same expected profit and the same worker's income, but the expected social welfare would differ:

$$\int_{\mu-h}^{\mu+h} U(\Pi p) + U_w dP \quad \text{Profit}$$

$$\int_{\mu-h}^{\mu+h} U(\Pi t) + U_w dP \quad \text{Area}$$

After manipulating the limits of integration and dropping worker's utility, which is the same, we must prove that

$$\int_{\mu-h}^{\mu} U(\Pi p) + U(\Pi t) dP > \int_{\mu}^{\mu+h} U(\Pi t) + U(\Pi p) dP$$

Because utility is flatter over the segment  $(\mu, \mu+h)$ , additional increases in income have lower utility—the slope of profits is lower for profit taxation:

$$Q(1 - R^* / (\mu Q - wL - mT)) < Q$$

Then it is true that foresters get more income over the interval  $(\mu-h, \mu)$ . Because the differences in utility are higher in this region, the inequality is true.

Q.E.D

### ***2-Optimal taxation using three instruments***

With three taxes available to the government, the problem is formulated in the traditional way: maximization of the expected social welfare function subject to a given revenue target.<sup>22</sup>

$$\text{Max } E(\text{SW}) = c \int_{P_{\min}}^{P_{\max}} U g(Y) + U w(wL) dP$$

$$\tau_e, \tau_p, \tau_t$$

$$\text{subject to } R^* = \tau_e \mu Q + \tau_t T + \tau_p \{[(1 - \tau_e) \mu Q - wL - (m + \tau_t)T]\}$$

Forester's profits for this problem are expressed as follows:

$$\Pi = (1 - \tau_p)[(1 - \tau_e)PQ - wL - (m + \tau_t)T]$$

The maximization generates the following system of nonlinear equations:

$$\int U' g [-(1 - \tau_p)PQ - (1 - \tau_p) \tau_e P \delta Q / \delta L \delta L / \delta \tau_e - w \delta L / \delta \tau_e] + U' w (w \delta L / \delta \tau_e) dP = \lambda [-(1 - \tau_p) \mu Q - (1 - \tau_p) \tau_e \mu \delta Q / \delta L \delta L / \delta \tau_e]$$

$$\int U' g [(1 - \tau_e)PQ - wL - (m + \tau_t)T] dP = \lambda [-(1 - \tau_e) \mu Q - wL - (m + \tau_t)T]$$

$$\int U' g [-T(1 - \tau_p)] dP = \lambda [-T(1 - \tau_p)]$$

After solving a system of nonlinear equations, the optimal solutions are obtained. However because export taxes have high-order expressions, for the optimal level of taxation there is no guarantee of an unique solution. Comparing the relative cost of raising one unit of revenue by

<sup>22</sup> The optimal taxation formulation is closer to the optimal linear taxation problem than to Ramsey's solution, although it has different elements than the traditional optimal income taxation solution.

each of the taxes, export taxation represents the most costly instrument for raising revenues again because of the distortion in labor affecting workers utility.

**Proposition 5:** *If a profit tax is used, the optimal value of the export tax rate is equal to zero.*

Proof:

Export taxation reduces forester profits over the interval in which marginal utility is increasing if it is used in combination with profit taxation. Export taxation could only be Pareto-improving in combination with area taxes when the variance of prices is large.

**Proposition 6:** *Using profit taxation alone is Pareto-superior than the combination of profit and area taxes.*

Proof:

Assuming that the optimal taxation rates have been obtained, the optimal profit tax is expressed as a function of the area tax:

$$\tau_p = R^* - \tau_t^* T / [\mu Q - wL - (m + \tau_t^*) T]$$

The optimal profit is now

$$\Pi = \{1 - R^* - \tau_t^* T / [\mu Q - wL - (m + \tau_t^*) T]\} (PQ - wL - (m + \tau_t) T)$$

Since there is no distortion in labor and government revenues are the same, use of the optimal mix yields equal expected profits. However, expected social welfare decreases, because profits are lower over the range  $(\mu-h, \mu)$ , in which the marginal utility of profits is increasing. A comparison of the slope of profits helps us to verify this:

$$[1 - R^* / (\mu - wL - mT)] Q < \{1 - R^* - \tau_t^* T / [\mu Q - wL - (m + \tau_t^*) T]\} Q$$

Q.E.D.

The conclusion derived from this model is that profit taxation is the more efficient policy to raise revenues given the price uncertainty faced by foresters. The welfare analysis hinges on firms being risk averse, while the government is risk neutral— it is this assumption that implies that a profit tax is superior to an area tax; if both are risk neutral, these two taxes are equivalent, and if the government is risk averse, the area tax dominates. The dominance of profit taxation relies on the following strong assumptions: (i) regulations, which allows optimal controls of the rate of cutting, and any externalities; (ii) risk aversity of firms; and (iii) no capital in the model, so the profit tax here is a tax on pure profit.

A proposal for medium-term reform could be to introduce a flat-rate profit tax to replace the export, stumpage, and area taxes. This assumes that tax administration is substantially improved, and that the big foresters are brought into the large taxpayers unit. This is not a proposal to be implemented in the short run but a horizon to give strategic direction to the taxation initiative in the forestry sector. This approach also assumes that the social optimum is achieved through enforcement of sustainable forest management practices, where companies and other agents abide by the established rules and are confined only to strictly defined areas of exploitation.