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The Distributive Effects of Forest Certification

A Theoretical Analysis

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Declaration

During the preparation of this master's thesis, I utilized various generative artificial intelligence tools throughout the entire research and writing process. Specifically, I used ChatGPT-4o and DeepL for translation and language improvements. Additionally, ChatGPT-4o supported me in identifying key themes, understanding economics papers, and verifying certain calculations. For citation generation, I relied on Scribbr and Zotero.

After using these generative artificial intelligences, I carefully reviewed and edited the content produced by the tools. I take full responsibility for the final content of this thesis.

By signing this declaration, I affirm that the content of this master's thesis reflects my original work, augmented by the responsible use of AI.

Apolline de Thibault de Boesinghe

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1. Introduction

Forest certification emerged in the early 1990s in response to growing concerns about deforestation, forest degradation, and biodiversity conservation, particularly in tropical regions (Rametsteiner & Simula, 2003). This movement aligns with a global awareness of environmental issues and sustainable development. A decisive moment was the 1992 Earth Summit in Rio de Janeiro, organized by the United Nations, which led to the adoption of the Forest Principles within Agenda 21. Although these commitments were not legally binding, they represented a major step forward in defining criteria for sustainable forest management (Perera & Vlosky, 2006). Sustainable forest management is defined as a "dynamic and evolving concept, which aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations" (Food and Agriculture Organization of the United Nations, n.d.).

While forest certification was initially conceived as a tool for promoting sustainable management, its economic consequences remain unevenly distributed. In particular, it raises important questions about who gains and who loses from its implementation. This research focuses on the distributive impact of forest certification, that is, how the costs and benefits of certification are shared across different actors particularly between Northern consumers and Southern producers, and among certified and uncertified producers within the Global South.

To answer this question, we construct a simple North-South trade model to analyse the impact of introducing forest certification in the South. In absence of certification, Southern producers can exploit their forest freely and sell timber directly to the North. However, with the introduction of forest certification, certified producers are constrained by sustainable harvesting limits. These limits ensure that they will be able to extract the same amount of forest in the next period. We assume that Northern consumers are uniformly willing to pay a price premium for certified timber, and that this premium is high enough to offset the productivity losses incurred by certified producers. This mechanism, known as an effective transfer, plays a central role in the model. Certification is assumed to be perfectly implemented and monitored. These simplifying assumptions tend to favour a positive impact of certification. The analysis focuses on a situation where the market is not fully saturated by certified timber, so that northern consumers also consume uncertified timber.

We first examine a static model and find that, following the introduction of certification, the price of certified timber rises due to the Northern consumers' preference for sustainable products and their willingness to pay more for them. Under the effective transfer assumption, certified producers see their income increase, while uncertified producers face a decline in income due to a drop in price of uncertified timber.

Second, we extend the model to a two-period dynamic setting. Certified producers benefit from their harvesting constraints in period 1, as they preserve forest resources and maintain stable production in period 2. In contrast, uncertified producers overexploit the forest in period 1, which reduces their production capacity in period 2. As a result, the overall timber supply declines in the second period, leading to higher timber prices due to scarcity. Certified producers, who can maintain their output levels, see their income increase. Uncertified producers, however, suffer a decline in income because the price increase is not sufficient to offset their reduced productivity

This work is organized as follows. Section 2 reviews the relevant literature. Section 3 presents the static model and its analysis. Section 4 extends the model to a dynamic setting and provides the corresponding analysis. Finally, section 5 concludes.

2. Literature review

2.1. Overview of Certification and Labelling

As environmental and social concerns intensify, labels and certifications are emerging as vital tools to guide responsible consumption. According to the FAO (2003), certification implies that an independent third party verifies that a product complies with specific standards, while the label serves as a visible proof of this compliance. These characteristics can be environmental, health, social, or even related to working conditions (Dankers & Liu, 2003). However, behind this seemingly simple tool, lie complex economic mechanisms, which the literature seeks to shed light on.

Several studies highlight that while labels can improve consumer information and encourage sustainable practices, their effectiveness depends on many factors: credibility, cost, companies'

strategic behaviours, and market structure (Baksi & Bose, 2006; Bonroy & Constantatos, 2014; L. Ibanez & Grolleau, 2007; Zago & Pick, 2004). Grover and Basal (2019) show that even imperfect certification can be beneficial, although an overabundance of labels undermines their credibility. On the other hand, Mason (2013) demonstrates that high certification costs can foster trust by discouraging false commitments. Baksi and Bose (2006) and Ibanez and Grolleau (2007) warn of the risks of loss of credibility and greenwashing in the absence of adequate controls or incentives. Cason and Gangadharan (2002) highlight that only certification verified by a third party can ensure environmental quality.

Market structure is also a determining factor. Baltzer (2012) shows that under imperfect competition, labelling reduces competition and increases market power. Zago and Pick (2004) suggest that public labelling can reduce welfare if the costs are high or if certified producers have market power.

On the demand side, the effect of labels depends on consumer perception. Basu and Hicks (2008) show that willingness to pay for a label depends on its actual performance. Bjørner et al. (2003) estimate that products featuring an eco-label can charge a price premium. However, a gap persists between stated intentions to pay this premium and actual purchasing behaviour (De Pelsmacker et al., 2005).

On the supply side, motivations for certification are primarily economic. Smallholder producers choose Fairtrade mainly to access better prices or new markets. Social aspects play a secondary role while environmental motivations are weak (Pyk & Abu Hatab, 2018). The costs associated with certification, audits, training, and adapting practices, represent a significant barrier to entry. This leads to self-selection among already organized producers, who are better equipped to meet the requirements. The impact on certified producers' income varies by context and often limited (Dragusanu et al., 2014; M. Ibanez & Blackman, 2016; Weber, 2011). De Janvry et al. (2015) show that the benefits are limited due to free entry, non-payment for quality, and certification costs, which significantly diminish the premium received.

Another major challenge is the multiplication of certification labels. A distinction is commonly drawn between NGO-supported labels, which are more demanding, and industry labels, which are more flexible and profit-oriented (Fischer & Lyon, 2014; Li & Van 'T Veld, 2015). Even in the absence of errors, Fischer and Lyon (2014) demonstrate that competition between labels can weaken overall environmental quality. In central Africa, Doremus (2020) reports that the introduction of a more flexible industrial label led to a 17% drop in environmental performance.

Nevertheless, Dufeu et al. (2014) demonstrate a complementarity effect between labels, which often outweighs concerns about redundancy and information overload. However, Li and Van't Veld (2015) nuance this by showing that a stable equilibrium can emerge, with the two types of labels targeting different segments. The State can then choose to introduce a single standard or a gradation of requirements. Public labels, whether compulsory or voluntary, are perceived as more credible and easier to understand and apply (Roe et al., 2014). Beyond the effects on producers, the structure of the certification market raises competitive issues. Baake and Naegele (2017) argue that this proliferation favours market segmentation and differentiation strategies, which can affect both perceived quality and competitive dynamics.

Finally, numerous studies examine the redistributive effects of labels. Durevall (2020) shows that fair trade benefits more to distributors in the Global North than to producers in the Global South. Dragusanu et al. (2022) note that only farms owners see a significant increase in their income, unlike farm workers. Baland and Duprez (2009) highlight unexpected effects of "no child labour" labels, such as the displacement of labour to uncertified sectors, without any overall reduction.

The majority of studies on fair trade rely on partial equilibrium models, focusing on a single market or a segment of the chain (Baumann et al., 2012; Bonroy & Constantatos, 2014; Podhorsky, 2015). In contrast, Baland et al. (2024) have developed a North-South general equilibrium model, integrating all agents and the redistributive effects between them.

Forest certification has also been analysed through theoretical models to analyse its economic effects. Few studies, including Guan et al. (2022) have used partial equilibrium models to assess the impacts of certification on prices, production and welfare, and have extended this approach with a general equilibrium model, incorporating environmental externalities. However, their analysis remains aggregate.

This thesis contributes to the literature by proposing a static North-South trade model and then extend to a two-period model. Unlike prior studies, it differentiates between certified and non-certified producers and allows for dynamic redistribution analysis. This novel framework captures the intertemporal wealth transfers induced by certification; a dimension largely overlooked in existing models.

To provide a clearer understanding of forest certification, which constitutes the central focus of this analysis, Section 2.2 presents an in-depth theorical discussion of the topic.

2.2. Forest Certification

2.2.1. Institutional Framework

The rise in environmental awareness during the 1990s lead to the creation of private initiatives promoting sustainable forest management. Among these initiatives, the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) are today the most internationally recognized systems. While FSC developed detailed global principles adapted locally, PEFC took a decentralized approach, endorsing national standards meeting its criteria (Garzon et al., 2020).

The Forest Stewardship Council (FSC) is an international organisation whose mission is to promote environmentally sound, socially equitable and economically viable forest management. To achieve this mission, the FSC has developed one of the most comprehensive standard for sustainable forest management (Garzon et al., 2020). These standards include 10 fundamental principles and 70 associated criteria, with indicators adapted to national and local contexts. These principles cover compliance with legislation, workers' rights, relations with indigenous peoples and communities, environmental protection and sustainable economic use of resources (Forest Stewardship Council, 2023).

Overall, forest certification processes generally follow five stages : initial commitment, preliminary assessment, main audit, certification approval and ongoing monitoring (Garzon et al., 2020). FSC audits are conducted by independent certification bodies accredited by the ASI, which ensures impartiality and credibility (Piketty et al., 2019). In case of minor non-conformities, corrective action must be taken within one year; major non-conformities must be corrected before certification is granted (Piketty et al., 2019). Certification remains valid for five years, subject to annual surveillance audits and a full reassessment at the end of the cycle (Forest Stewardship Council, 2015). A study of FSC standards in Brazil reveals that most indicators are clearly defined, offering limited scope for auditors' interpretation (Piketty & Garcia Drigo, 2018). However, the indicators that are more open to interpretation often concern important voluntary commitments, such as consulting local communities or taking social impacts into account. These elements, which are at the heart of sustainability, rely heavily on the auditor's judgement, which can lead to inconsistencies in implementation. In addition, the certification system tolerates a large number of minor non-conformities, including those linked

to legal requirements. This flexibility can compromise FSC's ability to ensure true regulatory compliance and weaken the credibility of certification (Piketty & Garcia Drigo, 2018).

Comparative studies indicate that FSC-certified forests achieve stronger ecological and social results, whereas PEFC-approved forests are more effective in maintaining forest productivity, thus supporting the long-term economic viability of forestry enterprises (Clark & Kozar, 2011; Wolff & Schweinle, 2022)

2.2.2. Drivers and Constraints to Certification Adoption

While certifications establish a rigorous framework for forest management, their adoption by economic actors follows distinct motivations. Companies seeking forest certification are mainly driven by customer demands, need to maintain competitiveness and increasing consumer pressure for environmentally friendly practices (Michal et al., 2019). In particular, countries with strong forest product export sectors are more likely to adopt certifications to remain competitive or to increase access to international markets, such as the European Union, where regulations strongly favour sustainable practices (Van Kooten et al., 2004).

On the consumer side, although environmental awareness is increasing, knowledge of forest certification remains limited. Price remains the main factor influencing purchasing decisions, and it is only when prices are comparable that some consumers prefer certified products (Michal et al., 2019). Furthermore, the willingness to pay a premium for sustainable products largely depends on consumers' income levels (Michal et al., 2019).
In developing countries, demand for certified products remains low. It is mainly the major European and North American retailers who demand FSC certification, more to secure their supply chains rather than to offer higher prices to producers (Bass, 1997). However, as certification remains a voluntary rather than a regulatory mechanism, its overall effectiveness remains limited (Haener & Luckert, 1998).

However, behind this gradual adoption, significant challenges persist, particularly for producers in the Global South. To obtain certification, producers have to overcome a number of structural obstacles. The first relates to land tenure: in many southern regions, land ownership is often undocumented or administered by the state, which is a major obstacle to obtaining certification (Thornber et al., 2000).

This situation is exacerbated by rigid standards requiring full compliance from the outset, and by limited technical and financial resources, which exacerbate the difficulties encountered by smallholders to bear the internal or external costs of certification (Cubbage et al., 2009; Fischer et al., 2005). These costs can weaken their competitiveness. In Ghana, for example, only 8 out of 224 companies have obtained FSC certification, due to the high cost of compliance, the lack of reliable information, weak public governance and cultural resistance to Western standards (Carlsen et al., 2012).

To facilitate the adoption of forest certification by smallholders, mechanisms like group certification have been developed to share audit and management costs, making certification more accessible (Perera & Vlosky, 2006). Despite these adjustments, certified forests in the South account for only 10% of total certified forests (Programme for the Endorsement of Forest Certification, 2024).

Although dominated by industrialised countries, certification is facing a major crisis in the South, where several countries such as Malaysia and Indonesia have introduced their own sustainable forest management standards (Thornber et al., 2000). Moreover, the multiplicity of certifications raises question about their international validity (Bass, 1997).

2.2.3. Environmental and Social Impacts

Despite these obstacles, it is important to assess the tangible impacts of certification on forests and local communities.

Forest certification has shown mixed results from an environmental point of view. While it contributes to an overall improvement in forest management practices, its direct impact on reducing deforestation remains limited. It mainly concerns forests destined for export, while agriculture remains the main driver of deforestation in these regions (Fischer et al., 2005). In Indonesia, for instance, the province of South Sumatra saw 63% of its natural forests disappear between 1990 and 2019, mainly as a result of the expansion of oil palm plantations and pulp and paper production (Purnomo et al., 2023). Still, some positive outcomes can be attributed to certification efforts. In Indonesia, certification helped reduce the deforestation rate by five percentage points in the areas concerned (Miteva et al., 2015). More broadly, around 60% of studies observe a decline in deforestation or forest degradation, particularly when stricter standards like those of the FSC are applied (Wolff & Schweinle, 2022). However, no significant difference between FSC and PEFC certification was found regarding the impact on forest loss.

This limited effectiveness might be explained by the fact that certification tends to focus more on improving forest management practices rather than on directly tackling deforestation (Yamamoto & Matsumoto, 2022).

Beyond the environmental aspect, forest certification also brings social benefits in certain regions. In Indonesia, it has reduced dependence on firewood, cut respiratory infections, improved nutrition and access to financial services for local communities (Miteva et al., 2015). In Ethiopia, sustainable management programmes enjoy strong local support when they succeed in reconciling ecological benefits with economic incentives (Tadesse et al., 2022).

2.2.4. Economic Viability

Beyond environmental and social impacts, the question of the economic viability of certification also deserves attention.
The viability of certification shows mixed results. About half of the studies reviewed identified a net benefit, while around a third concluded that the costs exceeded the benefits (Wolff & Schweinle, 2022). Profitability largely depends on factors like company size, product type, and whether the business is geared towards export markets.

In developed countries, consumers are generally willing to pay more for sustainable products (Aguilar & Vlosky, 2007). However, in emerging economies, price remains the main factor influencing purchases, which limits the potential impact of certification (Wolff & Schweinle, 2022). Although environmental awareness, trust in labels, and product type all play a role in consumer behaviour (Fischer et al., 2005), widespread lack of knowledge about certification schemes, along with the marketing strategies of large companies, often reduces the direct economic benefits for producers.
Even when price premiums exist, they are usually modest, often below 18% (Yamamoto et al., 2013). Some cases, like Bolivia, have shown that certified products can achieve premiums between 5% and 51%, which generally covers certification costs (Nebel et al., 2003).

However, these gains mostly benefit large companies, whereas small producers and local communities often remain on the side (Markopoulos, 1998; Nebel et al., 2003). More broadly, forest certification seems to act more as a strategic tool for big businesses to strengthen their brand image and secure supply chains, rather than as a direct way to raise incomes for producers

in the Global South (Cubbage et al., 2009). By reinforcing non-tariff trade barriers, certification can also deepen inequalities in access to international markets (Bulkan, n.d.; Chen et al., 2020). These findings reveal a structural imbalance between Northern and Southern countries in the distribution of benefits derived from forest certification. Building on these observations, the next section will examine these distributional effects using a static model.

3. The Static Model

3.1. Assumptions of the Model

The economic model considers two countries: the North and the South, which engage in direct trade under perfect competition. In each country, the population consists of a continuum of identical individuals, normalized to 1. Each individual has one unit of time, which they supply inelastically to the labour market. There is complete specialization: the North produces clothing while the South produces timber. The productivity of the North is denoted by γ, with each worker producing by γ units of clothing. For simplicity, clothing is taken as the numeraire good, with its price set to 1, implying that the income of a Northern worker is equal to γ.

In the South, there is a mass *N* identical producers, normalized to 1. Each producer owns a forest with a normalized initial stock of one unit. Producers can work in two different sectors: one producing certified wood and the other producing uncertified wood. The number of certified producers is fixed exogenously, reflecting restricted access to certification due to fixed costs, administrative burdens and informational constraints.
Uncertified producers overexploit the resource, operating with a productivity of σ, meaning each of them produces σ units of wood. Certified producers are constrained by sustainable harvesting rules and produce τ units of timber, with $\tau < \sigma$.

For simplicity, both certification and production are assumed to be costless. Certification is provided by NGOs. The monitoring system is assumed to be perfect, so certification is fully credible and trustworthy.

Let p_c and p_u represent the prices of certified and uncertified timber. Both prices are determined in competitive markets.

3.1.1. North

Consumers from the North consume both clothing and timber. They value the forest as public good and therefore support sustainable forest management and purchase certified timber.
The utility function of a Northern consumer is:

$$U_N = (1 + \lambda\mu)c_N^{\alpha}(t_N^c + t_N^u)^{1-\alpha} \quad (3.1)$$

Where $0 \leq \alpha \leq 1$, c_N corresponds to the amount of clothing, t_N^c the amount of certified timber, t_N^u the amount of uncertified timber consumed. λ is a dummy variable which equals 1 when consuming certified timber, and 0 otherwise. μ represents an extra utility benefit when consuming certified wood instead of uncertified timber.
The budget constraint for a Northern household is:

$$c_N + t_N^c p_c + t_N^u p_u = \gamma \ > 1$$

3.1.2. South

Southern producers can receive additional benefits by producing certified timber, as sustainable practices ensure long-term forest availability. The southern consumer purchases the least costly variety of wood because the two types of timber are perfect substitutes.
The utility from producing and consuming is:

$$U_S = c_S^{\alpha}(t_S^c + t_S^u)^{1-\alpha} + \ \delta\theta \quad (3.2)$$

Where $0 \leq \alpha \leq 1$, c_S corresponds to the amount of clothing, t_S^c the amount of certified timber, t_S^u the amount of uncertified timber consumed. The dummy variable δ equals 1 when producing under sustainable standards and 0 otherwise. θ represent an additional utility benefit from adopting sustainable harvesting practices.

3.2. Market Equilibrium Condition

Before certification, all producers were uncertified, meaning there was no product differentiation. The equilibrium price for uncertified timber, p^*, can thus be determined by equating the supply and the demand for clothes:

$$p^* = \frac{(1-\alpha)(\gamma+\sigma)}{\alpha\sigma} \quad (3.3)$$

In the certification equilibrium, there are a mass of n_c certified timber producers who adopt more sustainable harvesting methods. However, the mass of certified producers is too small to meet the entire wood demand from Northern consumers. As a result, part of this demand is fulfilled by uncertified timber. This outcome is due to the absence of free entry into the certification market. In practice, several barriers, such as higher costs and complex procedures, make certification particularly difficult for small producers in the South.

The equilibrium price of certified and uncertified timber must be equal so that Northern consumers are indifferent between the two types of timber:

$$p_c = p_u(1+\mu)^{\frac{1}{1-\alpha}} \tag{3.4}$$

Since $p_c > p_u$, the quantity of certified wood available on the market, $n_c\tau$, is entirely consumed by Northern consumers, who value sustainable extraction methods. As both types of timbers are perfect substitutes, Southern consumers whose primary concern is price, will consume only uncertified timber, which is less expensive.

The equilibrium price of uncertified timber is given by:

$$p_u = \frac{(1-\alpha)}{\alpha}\frac{\gamma}{(N-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}} \tag{3.5}$$

3.3. Static Effects of Certification on Prices and Producer Welfare

The introduction of forest certification creates a price differential between certified and uncertified timber. In equilibrium, Northern consumers are indifferent between two types of wood, which implies a willingness to pay a premium for certified timber. Certified producers face a sustainable productivity constraint. They must produce a smaller quantity than in the pre-certification period. As a result, the total supply of timber decreases. The resulting price adjustment depends on market characteristics.

Proposition 1: With the introduction of certification, the price of uncertified timber is lower than in pre-certification equilibrium if and only if

$$\frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)} < 1 \tag{3.6}$$

A sufficient condition for the price of certified wood to be larger is given by:

$$\frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)}(1+\mu)^{\frac{1}{1-\alpha}} > 1 \tag{3.7}$$

Proof: see Annexes

Certification introduce product differentiation. Southern consumers, primarily motivated by price, continue to purchase uncertified timber which remains cheaper. In contrast, Northern consumers shift their demand towards certified timber, valuing sustainability. Certified timber supply falls short of Northern demand, and this pushes the price above the price in the pre-certification area. Price changes influence consumer spending patterns. When the price of certified products rises (falls), total expenditure on this product tends to rise (decrease), while spending on non-certified products falls (increases).

As indicated in Proposition 1, the smaller the group of certified producers, the more likely it is the price of uncertified timber fall below its pre-certification level. This is because non-certified supply remains abundant, applying downward pressure on its price. Conversely, scarcity and increased willingness to pay push certified timber prices upward.

Proposition 2: With effective transfer, the introduction of forest certification has a positive impact on certified producers' income.

The effect of certification on certified producers is ambiguous due to opposing forces. On the one hand, certified producers benefit from a higher price due to the premium paid by Northern consumers for sustainable timber. On the other hand, they suffer from lower productivity, as sustainable exploitation reduces their harvest from σ in pre-certification to τ with certification, where $\tau < \sigma$. These opposing effects make the overall impact on income uncertain.

Their income before certification is:

$$R^* = \sigma p^* \tag{3.8}$$

Their income after certification is:

$$R_c = \tau p_c \tag{3.9}$$

To determine whether certification improves income, we use the effective transfer condition, which ensures that the price premium, originating from Northern consumers' willingness to pay more for sustainable timber, compensates for the productivity loss:

$$(p_c - p_u)\tau \geq (\sigma - \tau)p_u \tag{3.10}$$

$$\Leftrightarrow (1+\mu)^{\frac{1}{1-\alpha}}\tau \geq \sigma \tag{3.11}$$

With $p_c = p_u(1+\mu)^{\frac{1}{1-\alpha}}$

If this condition is verified, forest certification results in an effective transfer from the North to South: certified producers earn more monetary income despite harvesting less. Even if this condition is not satisfied, certified producers may still experience a net welfare increase thanks to non-monetary benefits. These are captured by the parameter θ, which reflects the long-term value of sustainable forest use, particularly in multi-period context where certified producers maintain their production capacity, unlike uncertified ones who face reduction due to their overharvesting.

Since the main advantage of certification lies in the guarantee of sustainable exploitation: the ability to continue exploiting the same quantity of forest over the long term, it is essential to adopt an intertemporal perspective. By analysing trends over several periods, we can truly measure the benefits that certified foresters derive from their initial efforts to restrict their use.

4. The Two-Period Dynamic Model

After analysing forest certification within a static, single period framework, it is useful to extend the analysis to a two-period intertemporal model. This extension clarifies how early sustainable choices affect long-term outcomes.

4.1. Assumptions of the Model

The model now includes two periods, two countries (North and South), and two goods (clothing and timber). Period 2 is the final one: no forest stock remains afterwards. This is a no-savings model, where workers spend all their income in the period in which it is earned.

The characteristics of the North remain unchanged across both periods. In contrast, Southern producers face intertemporal consequences based on their production decisions in period 1. The initial forest stock is normalized to one.

Non-certified producers overharvest the forest in period 1, extracting a share $\sigma > 0.5$. Since they do not benefit from any regeneration mechanism, the forest does not renew itself between periods. Their production capacity in period 2 is therefore limited to the unharvested quantity: $1 - \sigma$.

Certified producers, on the other hand, are required to follow a sustainable management strategy. They limit their extraction to τ in period 1 to preserve the resource. Thanks to natural regeneration, the available stock in period 2 becomes $(1 - \tau)(1 + g)$, where g is the regeneration rate. Certification imposes a sustainability condition requiring equal timber extraction across both periods, as expressed in the following equation:

$$\tau = (1 - \tau)(1 + g) \tag{4.1}$$

Solving yields

$$\tau = \frac{1 + g}{2 + g} \tag{4.2}$$

This condition defines the maximum extraction threshold that supports forest regeneration, ensuring stable production across periods for certified producers.

As in the static model, both certification and production are assumed to be costless. Certification, provided by NGOs, is supported by a perfect monitoring system that ensures full credibility and compliance.

Let p_c^t and p_u^t represent the prices of certified and uncertified timber, respectively, in period t. These prices are determined in competitive markets.

4.1.1. North

The intertemporal utility function of a Northern consumer is:

$$U_N = U_N^1 + \beta U_N^2 \tag{4.3}$$

Where $\beta \in (0,1)$ is the intertemporal discount factor, reflecting the consumer's preference for present consumption over future consumption.

Utility in each period $t \in \{1,2\}$ is defined as:

$$U_N^t = (1 + \lambda\mu)(c_N^t)^{\alpha}\left(t_N^{c,t} + t_N^{u,t}\right)^{1-\alpha} \tag{4.4}$$

Where $0 \leq \alpha \leq 1$, c_N corresponds to the amount of clothing, t_N^c the amount of certified timber, t_N^u the amount of uncertified timber consumed. λ is a dummy variable which equal 1 when

consuming certified timber, and 0 otherwise. μ represents an extra utility benefit when consuming certified wood instead of uncertified timber.

4.1.2. South

The intertemporal utility from producing and consuming is:

$$U_S = U_S^1 + \beta U_S^2 \tag{4.5}$$

Where $\beta \in (0,1)$ is the intertemporal discount factor, reflecting the consumer's preference for present consumption over future consumption.

Utility in each period $t \in \{1,2\}$ is defined as:

$$U_S^t = (c_S^t)^\alpha \left(t_S^{c,t} + t_S^{u,t}\right)^{1-\alpha} + \delta\theta \tag{4.6}$$

Where $0 \leq \alpha \leq 1$, c_S corresponds to the amount of clothing, t_S^c the amount of certified timber, t_S^u the amount of uncertified timber consumed. The dummy variable δ equals 1 when producing under sustainable standards and 0 otherwise. θ represent an extra utility benefit from adopting sustainable harvesting practices, reflecting the ability to sustain timber extraction over time.

4.2. Market Equilibrium Condition

Since uncertified producers overharvest in period 1, the total timber supply is high, keeping prices low. In contrast, in period 2, the remaining stock for non-certified producers is reduced, creating scarcity. This scarcity leads to an increase in the price of uncertified wood. As the production of uncertified wood decreases, its price increases. Keeping the market equilibrium condition for clothing, the price of uncertified wood is:

$$p_u^2 = \frac{(1-\alpha)}{\alpha} \frac{\gamma}{(1-n_c)(1-\sigma) + \frac{n_c}{1+g}(1+\mu)^{\frac{1}{1-\alpha}}} \tag{4.7}$$

As in period 1, the price of certified and uncertified timber are such that Northern consumers are indifferent between the two types:

$$p_c^2 = p_u^2 (1+\mu)^{\frac{1}{1-\alpha}} \tag{4.8}$$

As a result, both types of timber experience price increases in period 2 due to reduced overall supply, but only certified producers maintain a stable output quantity.

4.3. Intertemporal Effects of Certification on Income and Market Dynamics

Although certified producers reduce their extraction levels in period 1, their revenue does not decrease. This is due to the effective transfer mechanism: the clear redistribution of income from consumers in the Global North, who are willing to pay a price premium for certified timber, to certified producers in the Global South, who practice sustainable forest management. Effective transfer ensures that the certified producer's lower productivity to $(1-\sigma)$, is more than compensated by the higher price they receive. Uncertified producers on the other hand, see their income decline following the introduction of certification schemes, as the price of uncertified timber falls and production remains unchanged. As a result, their income in period 1 is below that of uncertified producers:

$$R_c^1 > R_u^1 \tag{4.9}$$

In period 2, the supply shortage resulting from the production loss caused by the overexploitation by uncertified producers in period 1, drive up the prices of both certified and uncertified timber. As a result, the effective transfer remains in place during period 2, further reinforcing the advantage secured by certified producers in the first period.

Proposition 3: Under effective transfer, the intertemporal revenue of certified producers is higher than the revenue of uncertified producers.

To evaluate the economic rationale for sustainable forest management, it is crucial to compare the intertemporal income of certified and uncertified producers. The total income over two periods is defined as follows:

$$R_c^{tot} = R_c^1 + \beta R_c^2 \tag{4.10}$$

$$R_u^{tot} = R_u^1 + \beta R_u^2 \tag{4.11}$$

Where $\beta \in (0,1)$ is the intertemporal discount factor, reflecting the producer's preference for present income over future income.

Given the effective transfer condition ensures that $R_c^1 > R_u^1$, it shows that for certification to be intertemporally profitable, it is sufficient that:

$$R_c^2 \geq R_u^2 \tag{4.12}$$

In other words, once certified producers are not disadvantaged in the short term, they only need to match or exceed uncertified producers' income in period 2 to ensure higher total income across both periods.

In period 2, uncertified producers face restricted output due to resource overharvesting. Their income is given by:

$$R_u^2 = (1 - \sigma)p_u^2 \tag{4.13}$$

Although the price rises as a result of scarcity, the drop in production volume outweighs the price effect, leading to lower overall income.

Certified producers, by contrast, benefit from stable production due to forest certification and higher prices due to market scarcity. Their income is

$$R_c^2 = (1 - \tau)(1 + g)p_c^2 \tag{4.14}$$

With $\tau = \frac{1+g}{2+g}$

Additionally, certified producers capture a growing market share. Their ability to maintain production while prices remain high places them in an increasingly dominant market position. Consumer preference for sustainable products reinforces the price premium, further strengthening their profitability.

Thus, as the income of uncertified producers declines in period 2 while that of certified producers increases, the condition $R_c^2 \geq R_u^2$ is met under effective transfer, confirming that:

$$R_c^{tot} \geq R_u^{tot} \tag{4.15}$$

The presence of an effective transfer in period 1 ensures that certified producers begin with a revenue advantage. Because this advantage is sustained in period 2 due to higher prices, market scarcity, and stable production certified producers outperform uncertified ones intertemporally. The economic case for certification is therefore robust: when the effective transfer condition holds, certified producers benefit from higher income both immediately and over time, while contributing to sustainable resource management.

Proposition 4: Non-certified producers are worse off with certification if and only if their total intertemporal income is lower than without certification.

$$R_u^{tot} < R^{tot} \tag{4.16}$$

$$\Leftrightarrow \beta(1 - \sigma)(p_u^2 - p^{*,2}) < \sigma(p^* - p_u^1) \tag{4.17}$$

Since non-certified producers have the same productivity in both scenarios, differences in income are entirely driven by price variations.

As established earlier, the price of uncertified timber in period 1 decreases with the introduction of certification: $p_u^1 < p^{*,1}$. Therefore, for non-certified producers not to be worse off, the price in period 2 must rise sufficiently to compensate for this initial loss.

However, although the prices of both certified and uncertified timber increase in period 2 due to declining supply, the rise is sharper in the absence of certification. Indeed, when no certification is in place, all producers deplete the forest, resulting in a sharper drop in total supply and a stronger price spike in period 2. With certification, certified producers follow a sustainable path and maintain part of the supply, which moderates the overall price rise.
Consequently, we expect $p_u^2 < p^{*,2}$, meaning that the price increase under certification is not strong enough to offset the earlier income loss. Consequently, non-certified producers are intertemporally worse off in the presence of certification.

Prior to certification, all producers faced a higher price in period 1 and benefited from a sharper price increase in period 2. With certification, the initial price drop and limited increase in period 2 result in a lower total income for non-certified producers compared to the pre-certification scenario.

5. Conclusion

This work proposes a theoretical analysis of the distributional effects of forest certification using a North-South trade model, first static and then intertemporal. The main contribution of the work lies in the explicit distinction between certified and non-certified producers in the South, and the study of their income trajectories over two periods. Under the hypothesis of an effective transfer, i.e. that the premium paid by consumers in the North offsets the fall in productivity linked to sustainable management, certified producers benefit from a higher income, both immediately and over time. Conversely, non-certified producers see their income fall, due to lower prices and degradation of their forests.
This approach highlights a redistributive effect that is little explored in the literature: although forest certification is effective in encouraging sustainable logging, it can exacerbate inequalities between stakeholders in the South, based on their access to certification.

There are several possible extensions to this research. More realistic assumptions could be incorporated, such as taking account of certification costs, uncertainty or the presence of intermediaries. The model could also be extended to a framework with an infinite horizon, or incorporate positive environmental externalities linked to the public-good nature of forests. Lastly, other distributive effects could be analysed for Southern producers.

This work is thus a first step towards a better understanding of the differentiated economic impacts of forest certification, from a sustainability and equity perspective.

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Annexes

1. Model Resolution

1.1. Pre-Certification Equilibrium

Demand for timber from the Noth $\frac{(1-\alpha)\gamma}{p}$

Demand for timber from the South $\frac{(1-\alpha)\sigma p}{p}$

With the supply of timber equal to σ

Therefore,

$$\frac{(1-\alpha)\gamma}{p^*} + \frac{(1-\alpha)\sigma p^*}{p^*} = \sigma$$

$$\Leftrightarrow p^* = \frac{(1-\alpha)(\gamma+\sigma)}{\alpha\sigma}$$

1.2. Post-Certification Equilibrium

1.2.1. The Static Model

In equilibrium, Northern consumers should be indifferent between the two types of timber:

$U_N^{c,1} = U_N^{u,1}$

$$\Leftrightarrow (1+\mu)(\alpha\gamma)^{\alpha}\left(\frac{(1-\alpha)\gamma}{p_c}\right)^{1-\alpha} = (\alpha\gamma)^{\alpha}\left(\frac{(1-\alpha)\gamma}{p_u}\right)^{1-\alpha}$$

$$\Leftrightarrow\ p_c = \left(\frac{(p_u)^{\frac{1}{1-\alpha}}}{(1+\mu)}\right)^{1-\alpha} \quad \Leftrightarrow p_c = p_u(1+\mu)^{\frac{1}{1-\alpha}}$$

Since the quantity of certified wood,$n_c\tau$, is not large enough, some northern consumers will consume uncertified wood. The Demand from the North for uncertified wood is given by:

$$\frac{(1-\alpha)\gamma - n_c\tau p_c}{p_u}$$

Where $(1-\alpha)\gamma - n_c\tau p_c$ is the residual budget not spent in certified wood.

In contrast, since $p_c > p_u$ southern producers only consume uncertified wood because their main concerns is the price of the wood they consume.

Demand for uncertified timber from certified producers in the South:

$$\frac{n_c(1-\alpha)p_c\tau}{p_u}$$

Demand for uncertified timber from uncertified producers in the South:

$$(N-n_c)\frac{(1-\alpha)p_u\sigma}{p_u} = (N-n_c)(1-\alpha)\sigma$$

With $p_c = p_u(1+\mu)^{\frac{1}{1-\alpha}}$

And since supply of uncertified wood is $(1-n_c)\sigma$, we get:

$$\frac{(1-\alpha)\gamma - n_c\tau p_c}{p_u} + \frac{n_c(1-\alpha)p_c\tau}{p_u} + (1-n_c)\frac{(1-\alpha)\sigma p_u}{p_u} = (1-n_c)\sigma$$

$$\Leftrightarrow\ p_u = \frac{(1-\alpha)}{\alpha}\frac{\gamma}{(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}}$$

1.2.2. The Two-Period Dynamic Model

In equilibrium, Northern consumers should be indifferent between the two types of timber:

$U_N^{c,2} = U_N^{u,2}$

$$\Leftrightarrow (1+\mu)(\alpha\gamma)^{\alpha}\left(\frac{(1-\alpha)\gamma}{p_c^2}\right)^{1-\alpha} = (\alpha\gamma)^{\alpha}\left(\frac{(1-\alpha)\gamma}{p_u^2}\right)^{1-\alpha}$$

$$\Leftrightarrow p_c^2 = \left(\frac{(p_u^2)^{\frac{1}{1-\alpha}}}{(1+\mu)}\right)^{1-\alpha} \Leftrightarrow p_c^2 = p_u^2(1+\mu)^{\frac{1}{1-\alpha}}$$

Since the quantity of certified wood,$n_c\tau$, is not large enough, some northern consumers will consume uncertified wood. The Demand from the North for uncertified wood is:

$$\frac{(1-\alpha)\gamma - (1-\tau g)n_s p_c^2}{p_u^2}$$

Where $(1-\alpha)\gamma - (1-\tau g)n_s p_c^2$ is the residual budget not spent in certified wood.

In contrast, since $p_c > p_u$ southern producers only consume uncertified wood because their main concerns is the price of the good, they consume.

The demand for uncertified timber from certified producers in the South

$$\frac{n_c(1-\alpha)(1-\tau g)p_c^2}{p_u^2}$$

The demand for uncertified timber from uncertified producers in the South:

$$(1-n_c)\frac{(1-\alpha)p_u^2(1-\sigma)}{p_u^2}$$

With $p_c^2 = p_u^2(1+\mu)^{\frac{1}{1-\alpha}}$

And since supply of uncertified wood is $(1-n_c)(1-\sigma)$, we get:

$$\frac{(1-\alpha)\gamma - (1-\tau g)n_c p_c^2}{p_u^2} + \frac{n_c(1-\alpha)(1-\tau g)p_c^2}{p_u^2} + (1-n_c)\frac{(1-\alpha)p_u^2(1-\sigma)}{p_u^2} = (1-n_c)(1-\sigma)$$

$$\Leftrightarrow p_u^2 = \frac{(1-\alpha)}{\alpha}\frac{\gamma}{(1-n_c)(1-\sigma) + \frac{n_c}{1+g}(1+\mu)^{\frac{1}{1-\alpha}}}$$

2. Proof

Proposition 1: With the introduction of a certification, the price of uncertified timber is lower than in the pre-certification equilibrium if and only if

$$\frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)} < 1$$

A sufficient condition for the price of certified wood to be larger is given by:

$$\frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)}(1+\mu)^{\frac{1}{1-\alpha}} > 1$$

Proof.

The aim of the proposition is to determine under which condition the introduction of certified leads to a decrease in the price of uncertified timber, that is when $p_u < p^*$. To do so, we directly compare the ratio $\frac{p_u}{p^*}$ to 1.

Using the expression for the post-certification price of uncertified timber and the pre-certification price, taking the ratio:

$$\frac{p_u}{p^*} = \frac{\frac{(1-\alpha)}{\alpha}\frac{\gamma}{(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}}}{\frac{(1-\alpha)(\gamma+\sigma)}{\alpha\sigma}} = \frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)}$$

We want to determine when $\frac{p_u}{p^*} < 1$, that is:

$$\frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)} < 1$$

This gives a necessary and sufficient condition for the price of uncertified timber to fall after certification.

We now complement this analysis by establishing a sufficient condition for the price of certified timber to exceed the pre-certification equilibrium price, which is when $p_c > p^*$. Using the fact that:

$$p_c = p_u(1+\mu)^{\frac{1}{1-\alpha}} \Rightarrow \frac{p_c}{p^*} = \frac{p_u}{p^*}(1+\mu)^{\frac{1}{1-\alpha}}$$

Therefore, a sufficient condition for $p_c > p^*$ is:

$$\frac{p_u}{p^*}(1+\mu)^{\frac{1}{1-\alpha}} > 1$$

Replacing $\frac{p_u}{p^*}$ by the expression above, we obtain the following sufficient condition:

$$\frac{\gamma\sigma}{\left[(1-n_c)\sigma + n_c\tau(1+\mu)^{\frac{1}{1-\alpha}}\right](\gamma+\sigma)}(1+\mu)^{\frac{1}{1-\alpha}} > 1$$

Note that this is a sufficient but not necessary condition for $\mathrm{p_c} > \mathrm{p}^*$, since it may still hold for certain parameter values even when the inequality is not strictly satisfied, when n_c is very small for instance.

■