Fraud and free riding in tropical forests – on the potential for certification to enforce sustainable resource use indirectly

Betrüger und Trittbrettfahrer im Tropenwald – zum Potential der Zertifizierung bei der Durchsetzung nachhaltiger Ressourcennutzung

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Abstract

Certification schemes for forest products are understood by many as a way to promote sustainable resource use when it is impossible to rely on direct enforcement of process standards. Based on the concept of 'Self-Enforcing Contracts', this study develops a market model that simulates the simultaneous partial equilibrium for both certified wood units and physically identical units that are produced without observing certain ecological standards. By illustrating the interplay of supply and demand in a world characterised by incomplete information, opportunistic behaviour and free riding, the model simulations, along with some empirical evidence from tropical forestry, indicate that certification will very likely fall short of preventing degradation of tropical forests. This is especially true in politically and economically unstable situations. Consequently, institutions other than markets are needed to govern the way natural resources are used. The problem of tropical forest degradation must be resolved primarily through forest legislation and improved governance structures and not through eco-labelling.

Key words

eco-labelling; asymmetric information; reputation; self-enforcing contracts; market equilibrium

Zusammenfassung

Zertifizierungssysteme für Forstprodukte werden häufig als ein Weg gesehen, eine nachhaltige Ressourcennutzung auch dann zu befördern, wenn eine direkte Durchsetzung von Prozessstandards unmöglich erscheint. Ausgehend vom Konzept 'sich selbst durchsetzender Vereinbarungen' wird in diesem Beitrag ein Model entwickelt, um das simultane partielle Marktgleichgewicht sowohl für zertifiziertes als auch für physisch identisches Holz, das ohne Beachtung bestimmter Umweltstandards produziert wird, darzustellen. Dabei wird das Zusammenspiel von Angebot und Nachfrage in einer Welt, die durch unvollständige Information, opportunistisches Verhalten und das Auftreten von Trittbrettfahrern gekennzeichnet ist, simuliert. Die Modellsimulationen sowie einige empirische Anhaltspunkte aus dem Bereich der tropischen Forstwirtschaft legen nahe, dass die Zertifizierung alleine sehr wahrscheinlich nicht ausreichen wird, die weitere Degradation tropischer Wälder zu verhindern. Dies gilt vor allem für politisch und ökonomisch instabile Länder. Folglich bedarf es neben Märkten anderer Institutionen, um die Art und Weise, wie natürliche Ressourcen genutzt werden, zu steuern. Dem Problem der Tropenwaldzerstörung ist in erster Linie durch Forstgesetze sowie verbesserte Institutionen und nicht durch Umweltsiegel zu begegnen.

Schlüsselwörter

Umweltsiegel (Zertifizierung); asymmetrische Information; Reputation; sich selbst durchsetzende Vereinbarungen; Marktgleichgewicht

1. Introduction

Ecolabels, signalling environmentally and socially unobjectionable production, are a market based instrument used to promote sustainable resource use. They have been developed for different fields, e.g., for tropical produce (cf. FAO, 2003a), fish (cf. OLORUNTUYI, 2004) and especially for timber (cf. RAMETSTEINER, 2002: 163; VAN KOOTEN et al., 2005: 859f.). OVERDEVEST and RICKENBACH (2006) identified three views of certification in the literature: it is seen either as a mechanism yielding market advantages, as a learning mechanism for knowledge transfer, or as a "signal of hard-to-observe or predict organizational characteristics and practices" (l.c.: 93). In this paper, we will focus on the latter view.

The basic idea of certification in tropical forestry was born in the early 1990s as an alternative to the boycott of tropical timber: environmentally-minded consumers pay a premium price for credibly labelled timber from well-managed forests. On the one hand, consumers were to be given assurance "by a reputable organization that the timber product was produced in an ecologically and socially acceptable way" (KIKER and PUTZ, 1997: 38). On the other hand, forest certification was intended to be used "as an instrument to transfer costs of sound forest management from forest owners to consumers" (MONTAGNINI and JORDAN, 2005: 144). The idea is particularly relevant for developing countries in the tropics that possess important forest sectors. Concerned citizens abroad have hardly any means of directly enforcing environmental protection measures in such countries. Hence, the objective of this study is to question whether conservation-conscious consumers will act significantly on natural resource use by making deliberate buying decisions.

The success of eco-labels varies widely. There is an abundant literature on the factors that determine demand for eco-labelled products as well as on the resulting possibilities of "green consumerism" to boost sustainable resource use (TEISL et al., 2002; ERIKSSON, 2003; CAVIGLIA-HARRIS, KAHN and GREEN, 2003; BJØRNER, HANSEN and CLIFFORD, 2004; NYBORG, HOWARTH and BREKKE, 2006). The question, however, of whether eco-labelling is effective in preventing ongoing resource degradation can only be answered when the behaviour of the suppliers is also considered. For the case of environmental pollution ARORA and GANGOPADHYAY

(1995) analysed voluntary overcompliance (i.e. cleaning more than required) by firms who have to face consumers with different willingness to pay for cleaner production. For two firms and given that consumers can identify cleaner producers, their game theoretical model yielded a market segmentation driven by different income levels. SEDJO and SWALLOW (2002: 276ff.) gave a detailed analysis of partial market equilibria for non-certified and voluntarily certified wood. Their conclusions cast doubts on the possible social benefits from certification, even though SEDJO and SWALLOW assumed perfectly competitive markets without any opportunistic behaviour. Also, FERRARO, UCHIDA and CONRAD (2005) neglected the latter aspect. Their dynamic analysis based on control theory indicated that direct payments had a higher efficiency than green price premiums (i.e. price mark-ups for voluntarily producing in an eco-friendly way). Studies applying concepts from institutional economics to forest certification have focussed on the underlying principal-agent relationships (KIKER and PUTZ, 1997) and on government roles (RAMETSTEINER, 2002).

Regarding imports of products which affect the environment, ENGEL (2004) modelled optimal trade policies under asymmetric information. KIRCHHOFF (2000) addressed the issue of compliance with voluntary standards. Using a two-period model involving reputation effects, she showed that a monopolistic firm is more inclined to produce eco-friendly products when there are relatively high price premiums, low additional costs, and a high probability of being detected when cheating. In the context of quality choice ENGEL (2006) also developed a two-period model which accounts for reputation effects in case of credence qualities. Such models generalise the self enforcement mechanism first described for experience qualities (see below) for detection probabilities less than one. HAMILTON and ZILBERMAN (2006) analysed both equilibrium fraud affected by model endogenous collective reputation and the related demand for eco-certified products in either an oligopoly or under monopolistic competition.

In contrast to the above studies, the following analysis is based on the benefits of individual reputation, and assumes third-party certification in a polypolistic market. It is important to understand under which conditions certification is able to prevent the overuse of forests or other natural resources. Going beyond the quoted literature the main objective of this paper is to integrate all relevant aspects that determine the success or failure of natural resource certification in a polypolistic market, i.e., supply (including the possibility of opportunistic behaviour), demand (including the preferences for externalities), as well as enforcement of the underlying sustainability standards by means of reputation effects. Therefore, the analytical framework in section 2 incorporates the concept of 'Self-Enforcing Contracts' into a polypolistic market model in order to overcome information asymmetries with respect to environmentally sound production. Section 3 contains a short overview of the current implementation of certification in the field of tropical forestry, and, based on the results of section 2, resorts to the available empirical evidence to answer the question of whether forest certification is a promising institution for ensuring sustainable resource use. Section 4 summarises and discusses the main conclusions.

2. Analytical framework

2.1 Theory of Self-Enforcing Agreements

As MONTAGNINI and JORDAN (2005: 109) point out, the environmental laws in many developing countries that regulate logging are often weak and poorly enforced. When direct enforcement does not work, a solution to this problem may lie in relying upon global market forces, forces which, even in remote regions of the world, indirectly enforce adequate wood harvesting.

Process standards that ensure sustainable resource harvesting usually result in extra costs. The amount of the extra costs depends on specific natural conditions as well as on prevailing economic and social circumstances. As a result, producers voluntarily complying with such standards need a price premium to cover their extra costs. If such a mark-up can be realised, the market mechanism may then solve environmental and/or social shortcomings. However, some producers may take advantage of the system by producing and selling commodities that do not meet the promised standards. If so, due to incomplete information and opportunistic behaviour, an optimal market solution will not come about.

Economic theory suggests different ways to overcome market failure because of asymmetric information. In our case, since the market for labelled natural resources such as certified tropical wood is subject to frequent transactions, the possibility of moral hazard and the *impossibility of exerting legal pressure* on the far away suppliers, the mechanism of 'Self-Enforcing Contracts' may ensure that the promised 'sustainability standards' are really met. In other words, some hidden product qualities are actually delivered when valuable reputations are at stake. A supplier who promises a better quality product can only make a credible commitment through its reputation, which can be lost through opportunistic behaviour.

A desired performance "will be implicitly enforced […] if the individual facing termination expects to earn a future quasi-rent stream the present discounted value of which is greater than the immediate short-run gain from breaching the contractual understanding" (KLEIN, 1985: 595). In other words, honesty must pay in order for honesty to be practiced (cf. FURUBOTN and RICHTER, 2005: 259, 261). Thus, a self-enforcing agreement is an agreement which an opportunistic partner holds to as long as he or she benefits more from continuing the agreement than he or she does from ending it. This principle, as well as the first model of self-enforcing agreements, was put forward by KLEIN and LEFFLER (1981); a simplified model was presented by STIGLITZ (1989). These authors analysed the case of an *experience quality*. Introducing the possibility that a poor quality remains undetected more generally, we will apply their approach to *credence qualities*.

2.1.1 Deriving an adequate 'No-Milking Condition'

On the one hand, today's net price obtained by an honest resource supplier is given by P_S - e.g., the price for certified wood from sustainable forestry - minus C_S, the annual marginal cost of sustainable production; C_S here includes all costs for environmentally adequate planting of seedlings,

selective logging, etc., as well as some firm level transaction costs linked to certification. The costs C_S may also contain charges incurred when preventing smallholder farmers from slashing and burning, e.g., by establishing alternative income possibilities, or other charges incurred when taking care of the interests of the local population. The corresponding sustainability standards are set by a third party. A per unit license fee f that covers the costs of the certification body is charged.

On the other hand, resource owners face the difference between the common market price P_M (independent of the manner of production) and the lower marginal costs C_M of environmentally harmful resource harvesting.[1] This net price must be multiplied by a factor α ($\alpha \geq 1$), since a production without considering environmental standards may lead to a higher permanent yearly wood output per unit of forest land. Hence, $\alpha - 1$ stands for the relative yield loss due to the standards. It is assumed that in both production systems wood will be produced year after year from now until eternity. However, in case of certified production, e.g. due to continuous set-aside of forest land for reasons of nature conservation, less wood per unit of forest land may be produced (in case both systems yield the same permanent output α is equal to 1). Then, $\alpha(P_M - C_M)$ are the opportunity costs of the certified wood that result from the inability of the overall resource stock to be increased without limits, so that the resource owners will usually realise a scarcity rent.

The net present values of the profits of today and of the future related to the supplier's actual behaviour determine whether an opportunistic supplier complies with promised 'sustainability standards' or not. The net present value, in the case of compliance with the sustainability standards ($NPVC$), is given by the price-cost-difference today plus the sum of the price-cost-differences in the future, which have to be discounted at a rate d:

$$NPVC_n = P_S - f - C_S + (P_S - f - C_S)(1+d)^{-1} + \\ + (P_S - f - C_S)(1+d)^{-2} + \ldots + (P_S - f - C_S)(1+d)^{-n}.$$

Assuming both constant annual net prices $P_S - f - C_S$ and the number of years n approaching infinity, the net present value of compliance can be transformed into:

$$NPVC_\infty = (P_S - f - C_S)\left(1 + \frac{1}{d}\right).$$

Now, apart from moral concerns, it might be a good bargain to obtain the high premium price P_S for resource units harvested at the low costs of a 'robber economy' C_M. Consequently, an opportunistic supplier will also consider the net present value which results from continuously violating the promised standards (case of moral hazard). Introducing the known probability w of being discovered when cheating (which depends on the frequency of annual sample inspections) and assuming that w as well as all prices and costs are constant over time and that n approaches infinity, the corresponding expected net present value $NPVV$ gives:

$$NPVV_\infty = \alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d} + \\ + \frac{1-w}{1+d}\left[\alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}\right] + \ldots + \\ + \left(\frac{1-w}{1+d}\right)^{\infty}\left[\alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}\right] \\ = \left[\alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}\right]\sum_0^\infty\left(\frac{1-w}{1+d}\right)^n \\ = \left[\alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}\right]\frac{1+d}{d+w}$$

(for a more detailed explanation see footnote[2]).

Every risk-neutral opportunistic producer will comply with the promised sustainability standards as long as $NPVC_\infty \geq NPVV_\infty$, i.e.:

$$(P_S - f - C_S)\left(1 + \frac{1}{d}\right) \\ \geq \left[\alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}\right]\frac{1+d}{d+w}$$

$$\Leftrightarrow (P_S - f - C_S)\frac{d+w}{d} \\ \geq \alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}$$

[1] In the following we will always refer to the environmental standards linked to sustainable production. Anyway, without changing the outcome of the following analysis the cost difference $C_S - C_M$ could also contain costs due to additional social standards to be observed by the certified units.

[2] $\sum_0^\infty\left(\frac{1-w}{1+d}\right)^n = \frac{1+d}{d+w}$ *since* $0 < \frac{1-w}{1+d} < 1$.

According to the concept of self-enforcing agreements there is no direct punishment or fine imposed on the cheater. At present, a cheater earns $\alpha(P_S - f - C_S)$ for sure (cf. the first term of $NPVV_\infty$). When being caught, which happens at probability w, he is supposed to lose forever the entitlement to sell certified wood; hence, the resulting expected value (i.e. the expected present value of the rent from conventional wood production) is $w\alpha(P_M - C_M)/d$. When not being detected this year, which happens at a probability of $1 - w$, he can cheat again next year, getting once more $\alpha(P_S - f - C_S)$ and expecting $w\alpha(P_M - C_M)/d$ which now both have to be discounted (dividing them by $1 + d$); moreover again, at a probability of $1 - w$ he will not be caught, so that for the year after the same reasoning is to be done again etc. The corresponding infinite regress leads to the above first formula for $NPVV_\infty$. An alternative way to derive $NPVV_\infty$ (cf. the similar approach by VETTER and KARANTININIS, 2002: 273f.) results from the fact that a cheater undetected this year (which happens at a probability of $1 - w$) next year will be faced with the same situation and the same $NPVV_\infty$ as today. The corresponding equation gives:

$$NPVV_\infty = \alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d} + (1-w)\frac{NPVV_\infty}{1+d}$$

$$\Leftrightarrow \quad NPVV_\infty = \left[\alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d}\right]\frac{1+d}{d+w}.$$

$$<=> P_S - f - C_S \geq \alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d} - w\frac{P_S - f - C_S}{d}$$

$$(1) \quad <=> \quad (P_S - f - C_S)\left(1 + \frac{1}{d}\right) \geq \alpha(P_S - f - C_M) + w\frac{\alpha(P_M - C_M)}{d} + (1-w)\frac{(P_S - f - C_S)}{d}.$$

Hence, the opportunistic producer compares the present value of the rent that he or she will certainly receive when being honest ($(P_S - f - C_S)(1+1/d)$) with the immediate certain profit from cheating ($\alpha(P_S - f - C_M)$), plus the expected present value of the future rent when cheating and being caught ($w\alpha(P_M - C_M)/d$) plus the expected present value of the future possible rent when cheating and remaining undiscovered ($(1 - w)(P_S - f - C_S)/d$). Since, by definition $C_S > C_M$, inequality (1) shows that at $w = 0$, no opportunistic producer will comply with the standards.

If detected when cheating the opportunistic supplier will merely obtain the common market price P_M in all the following years, resulting in the constant rent $\alpha(P_M - C_M)$. Otherwise, if the violation of standards is not detected (which happens at a probability of $1 - w$), he or she will keep the option of later realising the rent $P_S - f - C_S$. In STIGLITZ's (1989) model for an experience quality (i.e. $w = 1$), P_M simply equals C_M, since in contrast to natural resources, perfect competition for a typical 'man-made' commodity finally leads to a market equilibrium without any scarcity rent.[3]

Rearranging inequality (1) yields the fundamental condition for compliance:

$$(1a) \quad P_S - f - C_S \geq P_M - C_M + (\alpha-1)(P_M - C_M) + (\alpha-1)\frac{d}{w}(P_S - f - C_M) + \frac{d}{w}(C_S - C_M),$$

which is an enlarged version of the condition found by LIPPERT (2005) and can also be expressed as:

$$(1b) \quad \Delta P = P_S - P_M \geq C_S - C_M + (\alpha-1)(P_M - C_M) + f + (\alpha-1)\frac{d}{w}(P_S - f - C_M) + \frac{d}{w}(C_S - C_M).$$

2.1.2 Conclusions from the 'No-Milking Condition'

From (1a), it follows that in order to make opportunistic producers comply, for $w = 1$ the rent from certified production $P_S - f - C_S$ must at least cover the net benefits foregone from unsustainable production (i.e., $P_M - C_M$ along with the net value of the reduced yield $(\alpha - 1)(P_M - C_M)$), plus the interest that could be generated by the one-time profit from the yield increment $d(\alpha - 1)(P_S - f - C_M)$ and the cost savings $d(C_S - C_M)$ when cheating today. Correspondingly, for a discount rate of $d = 0$, the rent from certified production $P_S - f - C_S$ must at least compensate for the opportunity costs $\alpha(P_M - C_M)$. For $\alpha = 1$ according to (1b), the necessary minimum mark-up is $\Delta P = f + (1 + d/w)(C_S - C_M)$. Following SHAPIRO (1983: 666), similar restrictions are usually referred to as 'No-Milking Conditions'. Here, an *opportunistic* producer must realise a mark-up ΔP that not only covers his extra costs $C_S - C_M$, but even exceeds them.

In a partial polypolistic market equilibrium, which, like every market equilibrium, is supposed to be attained after a certain time, only complying opportunistic suppliers will remain on the market for sustainably produced wood, because by and by non-complying producers will have been detected. For simplicity, it is assumed that detected non-compliers will be forever excluded from the certified wood market. For all finally remaining sustainable producers the 'No-Milking Condition' will apply (i.e. a self-enforcing equilibrium will be reached). Given (1a) this implies that for the marginal complying opportunist in the self-enforcing equilibrium, the following equation holds:

$$(1c) \quad G\left(P_S; P_M; C_S; C_M; f; \frac{d}{w}; \alpha\right) = P_S - f - C_S - \alpha(P_M - C_M) - (\alpha-1)\frac{d}{w}(P_S - f - C_M) - \frac{d}{w}(C_S - C_M) = 0.$$

Hence, a small reduction of $G(.)$ due to a *ceteris paribus* change of one of its variables (i.e. $G'(.) < 0$) will increase the amount of conventional production in the equilibrium, since then in a big polypoly with many producers there will be at least one more producer for whom (1) does not hold any longer. In other words: if $G'(.) < 0$, then due to the variable change considered (1c) will become less than zero for the marginal complying producer; thus, for this person the equality sign in (1) will be changed to "<". This means that he will start to cheat. Sooner or later he will be discovered and excluded from the certification scheme. Consequently, there will be one more conventional producer.

Conversely, an increase of $G(.)$ (i.e. $G'(.) > 0$) will reduce the number of conventional producers in the equilibrium, since then there will be at least one more producer for whom (1) holds. As $G(.)$ yields the partial derivatives

$$\frac{\partial G}{\partial P_M} = -\alpha < 0; \quad \frac{\partial G}{\partial C_S} = -\left(1 + \frac{d}{w}\right) < 0; \quad \frac{\partial G}{\partial C_M} = \alpha\left(1 + \frac{d}{w}\right) > 0,$$

a *ceteris paribus* increase of P_M as well as of C_S will finally result in more conventional production; whereas rising costs C_M will reduce the number of producers who do not fulfil the standards. More conventional production will also result from a rising factor α since

$$\frac{\partial G}{\partial \alpha} = -(P_M - C_M) - \frac{d}{w}(P_S - f - C_M) < 0.$$

From

$$\frac{\partial G}{\partial (P_S - f)} = 1 - (\alpha - 1)\frac{d}{w},$$

it follows that a rising price P_S or a reduced fee f per unit of certified production will increase $G(.)$, and therefore increase the number of complying opportunists as long as

$$1 - (\alpha-1)\frac{d}{w} > 0 \quad <=> \quad \alpha < 1 + \frac{w}{d}.$$

[3] For a 'Self-Enforcing Contract' model, similar to the model developed here, with infinite time horizon and which also includes the probability of being discovered when cheating, but no rent for the low quality product, see VETTER and KARANTININIS (2002).

For $\alpha = 1$ and $w > 0$ this is always given; the intuitive reason is that then, for the marginal producer the additional short-term benefits from cheating are clearly less than the corresponding present value of the expected benefits lost in future. In contrast, in case of a high factor α, a low w and/or a high discount rate d a rising price P_S or a reduced fee f can induce the marginal complying producer to cheat (leading to less sustainable production in the equilibrium), since then the additional *expected* rents lost in future are low and strongly discounted, whereas the short-term benefit from cheating is relatively important due to the high α. Of course, for $w = 0$ a rising price P_S or a reduced fee f can never hinder cheating, because then, due to no risk of being detected, no future rents will be lost. Finally,

$$\frac{\partial G}{\partial (d/w)} = -(\alpha - 1)(P_S - f - C_M) - (C_S - C_M) < 0$$

since $C_S > C_M$; $P_S - f > C_M$ and $\alpha \geq 1$. Consequently, a rising common discount rate d and a decreasing probability w *ceteris paribus* both increase conventional production.[4]

Merely considering the partial derivatives *GN(.)* of the 'No-Milking Condition' (1) some major conclusions can be drawn. Since the *necessary* premium ΔP required to prevent cheating has to cover at least the extra costs $C_S - C_M$ (cf. the right hand side of (1b)),

(C.1) the premium ΔP has to be the higher the more the costs C_M can be decreased or the more external costs can be shifted onto the general public (i.e. the weaker the respective legislation and law enforcement are)[5].

(C.2) likewise, the premium ΔP has to be the higher the greater the site specific costs - contained in C_S - to prevent resource degradation (e.g., degradation of forests that have been made accessible for sustainable wood use).

Furthermore, the greater the discount rate d is, the higher the premium has to be. This is due to two factors: First, as the interest rate in (1b) illustrates, the discount rate directly affects the necessary premium: since $MG/M(d/w) < 0$ (see above),

(C.3) for the marginal opportunistic supplier ΔP has to be higher in case of a greater ratio of the personal discount rate d and the detection probability w (this conclusion applies to a situation where $(\alpha - 1)\, d / w < 1$ because only then a higher price P_S can offset the effect of an increased ratio d/w, cf. (1b)).

Second, the costs C_S usually increase with d, since costly preventive measures have to be taken immediately. The costs in the case of a 'robber economy' however, show a tendency to decrease along with d, because the relevant damages like those resulting from soil erosion will arise later.[6] In this sense, the discount rate has an indirect minimum premium increasing effect.

Conclusions (C.1) to (C.3) are quite similar to the conclusions found by ENGEL (2006: 125) who, however, used a different model approach.

2.2 Partial Market Equilibrium

2.2.1 Model equations

Now, in a polypolistic situation with a significant share of opportunistic suppliers, the partial market equilibrium for two markets will be modelled as follows: a market for sustainably harvested units q_S and a market for physically identical units q_M, in which consumers do not care about the origin of the product (i.e. the 'market for conventional wood'). The corresponding equilibrium implies that the following six model equations must hold:

'No-Milking-Condition':

$$(1c)\quad P_S - f - C_S - \alpha(P_M - C_M) - (\alpha - 1)\frac{d}{w}(P_S - f - C_M) - \frac{d}{w}(C_S - C_M) = 0.$$

System of two demand functions:

$$(2a)\quad \ln q_S = -v_S \ln P_S + z_S^{\,M} \ln P_M + u_S;$$

$$(2b)\quad \ln q_M = z_M^{\,S} \ln P_S - v_M \ln P_M + u_M;$$

(v_S and v_M are *price elasticities,* $z_S^{\,M}$ and $z_M^{\,S}$ are *cross price elasticities of demand,* u_S and u_M are the remaining *parameters of the demand functions*).

Two supply functions:

$$(3a)\quad C_S = C_S^* + h\, q_S;$$

$$(3b)\quad C_M = C_M^* + g\, q_M;$$

(C_S^*, h, C_M^* and g are *parameters of the supply functions*).

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4 However, *deliberately* increasing w, which means more frequent (costly) inspections by the certification body, in the end, will also increase the license fee f (i.e. $\partial f/\partial w = f'(w) > 0$) to be borne by the suppliers. Hence, more inspections are only useful when

$$\frac{\partial G}{\partial w} = -f'(w) + (\alpha - 1)\left[(P_S - f - C_M)\frac{d}{w^2} + \frac{d}{w} f'(w)\right] + \frac{d}{w^2}(C_S - C_M) > 0.$$

Since $f'(w) > 0$, $C_S > C_M$, $P_S - f > C_M$ and $\alpha \geq 1$ this inequality always holds for $w \approx 0$.

5 When at least part of the existing laws regarding conventional production are not enforced, this means that in practice some costly environmental standards need not to be observed. Consequently, the supplier's effective costs C_M are lowered.

6 The annual costs C_S and C_M can be further subdivided and analyzed with respect to changes of the discount rate d as follows:

$$C_S = C_{S.R} + C_{S.On0}\, d \quad \Rightarrow \quad C_S'(d) = C_{S.On0} > 0;$$

$$C_M = C_{M.R} + \frac{C_{M.OnT}\, d}{(1+d)^T}$$

$$\Rightarrow C_M'(d) = C_{M.OnT}\,\frac{1 - d\,(T-1)}{(1+d)^{T+1}} < 0 \quad for\ d > \frac{1}{T-1}$$

with $C_{S.R}$ ($C_{M.R}$) = regular annual cost of sustainable (conventional) wood production,

$C_{S.On0}$ = one-time cost for preventive measures, arising today (t = 0),

$C_{M.OnT}$ = one-time cost for repairing damages arising in T years (t = T).

Resource availability constraint:

(4) $q_M = Q - \alpha\, q_S$

with q_S = units harvested annually in accordance with the sustainability standards,
q_M = units harvested annually without complying with the standards,
Q = maximum amount of annually harvestable resource units (proportionate to the resource base, e.g., the available forest land),
α = 1 + the relative yield loss due to the certification standards ($\alpha \geq 1$).

All parameters and variables used are greater than or equal to zero. As the totally available resource base (which is always entirely used for production) is strictly limited within the model, there is a maximum quantity of overall annual production. The quantity in the example of tropical wood production in a benchmark situation, when only conventional wood is harvested, is given by $q_M = Q$. When some suppliers switch from conventional to sustainable harvesting, the corresponding rise in the production of certified wood will be less than the decline on the common wood market. This is because every hectare of conventional forest that is converted into a certified area will yield less wood, at least as long as certification requires higher standards such as more set aside land, reduced-impact logging, etc. Consequently, for every unit of q_S, society has to renounce to α units of q_M.

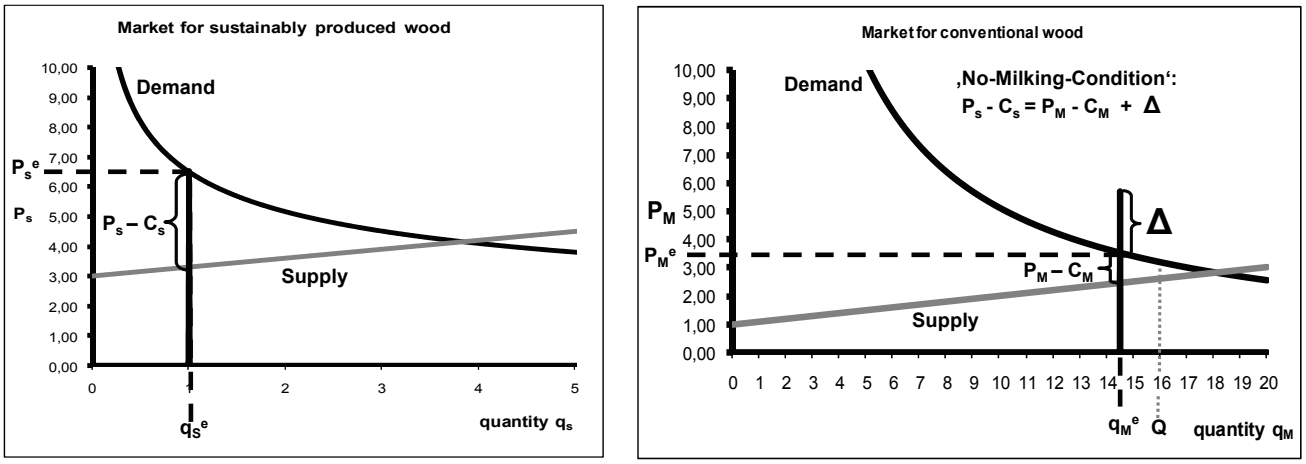
Figure 1 shows the partial market equilibrium, along with the rents contained on both sides of equation (1c) for a set of parameters for equations (1) through (4), which yields a realistic shape of the corresponding demand and supply functions. This leads to the equilibrium price difference ($\Delta P = P_S - P_M$) reflected in figure 1, where the 'No-Milking Condition' just holds. In such an equilibrium no producer will switch any more from one production system to the other and all cheaters having been detected and definitely excluded from certified production the rents $P_S - C_S$ will be sufficient to indirectly enforce compliance with the sustainability standards.

In the outlined example, the ratio d/w is equal to 0.5; this corresponds, for example, to a discount rate d of 10% and a detection probability w of 20%. Whereas demand for conventional wood in figure 1 is thought to be relatively inelastic ($v_M = 1$), the demand for sustainably harvested wood is represented as more elastic ($v_S = 3$), since the corresponding products are seen as 'luxury goods.' In this context, public procurement policies play a major role, as various administrations have introduced rules for the 'green' procurement of wood products (cf. ATYI and SIMULA, 2002: 18). Given their limited budgets, however, it is likely that many public authorities will simply stop purchasing tropical timber in a situation of strongly increasing prices.

2.2.2 Conclusions from the market model

In the market, a higher premium results as soon as some of the suppliers switch from sustainable to conventional resource harvesting. As already stated, figure 1 reflects the equilibrium price difference ($\Delta P = P_S - P_M$), where the 'No-Milking Condition' just holds and where no producer will switch any more from one production system to the other. Increasing the ratio d/w in the model underlying figure 1 from 0.5 to 1.0, while keeping all else equal, leads to a rise of q_M by 6.5% (from 14.50 units to 15.44 units) in the new equilibrium. In contrast to this, a low ratio d/w of 0.02 entails a decline of the conventionally cultivated forest area by 7.1% (corresponding to a decline from 14.50 to 13.47 units) when compared with the benchmark situation of figure 1. The ratio d/w tends to be high in countries that possess inefficient institutions, insufficient transparency or political instability, especially when the resource owners have to face a great risk of expropriation, because such a situation results in both a low detection probability w and a high discount rate d applied by the resource owners.

Figure 1. Simultaneous market equilibrium for sustainably produced wood and for conventional wood, in cases of large amounts of tropical forests

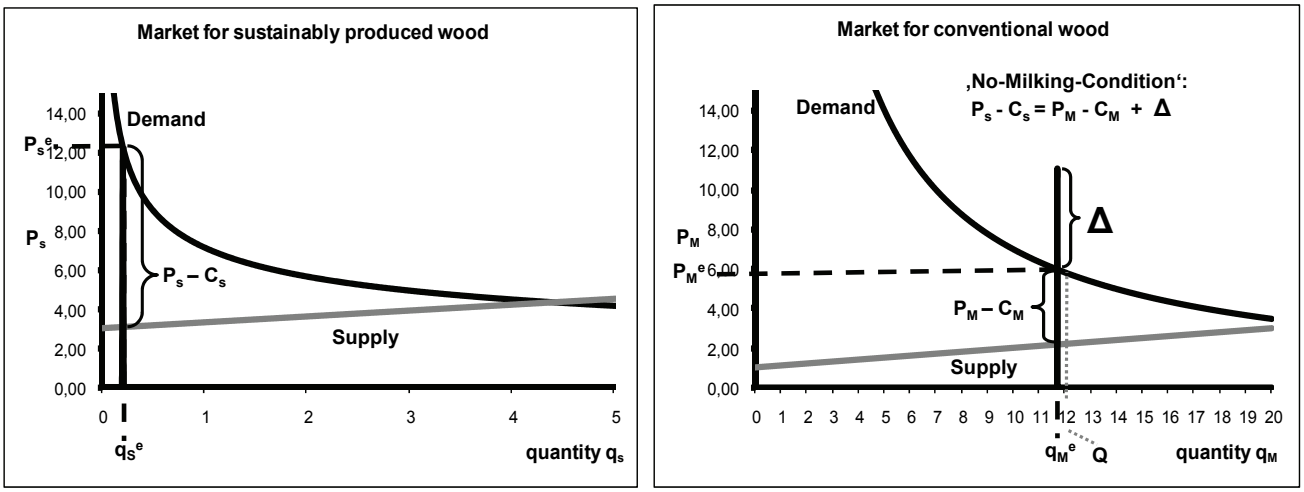


$$\Delta = f + (\alpha - 1)(P_M - C_M) + (\alpha - 1)\frac{d}{w}(P_S - f - C_M) + \frac{d}{w}(C_S - C_M) \quad (cf.\ condition\ (1c)).$$

Note: The parameters (cf. equations (1c) to (4)) underlying the market equilibrium represented in the figure are: $C_S^* = 3$; $C_M^* = 1$; $h = 0.3$; $g = 0.1$; $v_S = 3$; $v_M = 1$; $z_S^M = z_M^S = 0.5$; $u_S = 5$; $u_M = 3$; $d/w = 0.5$; $f = 0.2$; $\alpha = 1.5$; $\boldsymbol{Q = 16}$. – P_S^e, q_S^e and P_M^e, q_M^e are the equilibrium prices and quantities.

Source: author

Figure 2. Simultaneous market equilibrium for sustainably produced wood and for conventional wood in cases of low amounts of tropical forests



$$\Delta = f + (\alpha - 1)(P_M - C_M) + (\alpha - 1)\frac{d}{w}(P_S - f - C_M) + \frac{d}{w}(C_S - C_M) \quad (cf.\ condition\ (1c)).$$

Note: The parameters (cf. equations (1c) to (4)) underlying the market equilibrium represented in the figure are: $C_S^* = 3$; $C_M^* = 1$; $h = 0.3$; $g = 0.1$; $v_S = 3$; $v_M = 1$; $z_S^M = z_M^S = 0.5$; $u_S = 5$; $u_M = 3$; $d/w = 0.5$; $f = 0.2$; $\alpha = 1.5$; $\boldsymbol{Q = 12}$. – P_S^e, q_S^e and P_M^e, q_M^e are the equilibrium prices and quantities.

Source: author

Obviously, compared to a situation where $q_M = Q$, certification tends to increase prices for non-certified wood. Unfortunately, this makes both environmentally harmful wood harvesting and illegal logging more attractive if certification really is successful. Even worse, this applies to a great degree to benchmark situations where the resource base is already relatively scarce (i.e., a lower Q, cf. figure 2).

Consequently, assuming the same system of demand functions as before, at equilibrium, then much less forestland will be 'saved' by means of certification (compare the two differences $Q - q_M^e$ in both figures). Whereas in figure 1, 9.4% of the entire forest land is sustainably managed at the end, in figure 2 this value is only 2.9%. The reason for this is that in figure 2, there is an important scarcity rent already at $q_M = Q$, and hence higher opportunity costs $\alpha(P_M - C_M)$. In addition to this, there is also a steeper slope of the demand function at $q_M = Q$. To outweigh the greater opportunity costs as well as the greater incentive resulting from the profits related to cheating, the price P_S must now be higher. Consequently, for a realistic shape of the relevant demand and supply functions,

(C.4) the more critical the state of the resource in question already is, the less ability certification schemes have to prevent resource bases from degradation.[7]

The fifth conclusion refers to the role of the demand for sustainably harvested resources. If the demand is weak, the equilibrium brought about by market forces results in more conventional and less certified products. Eventually, the success of certification in ensuring sustainable resource use abroad depends, to a large extent, on demand, since,

(C.5) the fewer consumers that are willing to buy certified products (i.e. the lower the demand function for sustainably produced wood), the lower the equilibrium quantity q_S^e that will finally be realised.

It is, however, very likely that the *effective* demand for certified products will be insufficient, according to peoples' real preferences. The reason for this is that no one can be excluded from enjoying the external benefits related to environmentally friendly resource use. As in many other fields of environmental protection, a *social dilemma* occurs: many consumers may prefer to buy cheap products and rely on those who purchase certified commodities to provide for public goods such as biodiversity preservation or carbon dioxide storage. In the example of tropical forests, as certified and non-certified wood differs only in its method of production, but not in the qualities related to its use, a customer draws no additional private benefit from the more expensive wood products. In contrast to this, people who pay higher prices, e.g., for organic vegetables, may hope to get healthier food and thus to increase their private utility.

3. Empirical evidence

Is it realistic to believe that certification can play a major role in counteracting ongoing overuse and loss of tropical forests (cf. BARBIER, 2004)? According to KRAXNER et al. (2006: 98, 101), the worldwide certified forest area in 2006 amounted to 270 million hectares, which is approximately 7% of world's total forest area. It is important to note that 87.5% of this area is located in North America and in the EU/EFTA region. Consequently, KRAXNER et al. (2006: 101) conclude that while "the original driver for certification might have been uncontrolled deforestation in the tropics, in practice, its adoption has been far more successful in the

[7] This conclusion is only proven for the set of (realistic) parameters used in the example above. We do not provide a calculation of the range of demand elasticities and coefficients of the supply functions to which it applies. Intuitively, (C.4) is supposed to be valid for a huge set of supply and demand functions shaped similarly as those represented in figures 1 and 2.

northern than in the southern hemisphere, in the temperate and boreal regions than in the tropical zone, and in the developed than in the developing world." RAMETSTEINER and SIMULA (2003, 92f.) obtained similar results.

As far as tropical forestry is concerned, the most prominent certification scheme - considered by NGOs to be most independent and rigorous in its requirements (FERN, 2004) - has been implemented by the *Forest Stewardship Council (FSC)*. This organisation develops principles and criteria (cf. FSC, 2002) which have to be incorporated into regional standards for ecologically and socially well managed forestry. The FSC both awards a label to products that come from corresponding forest sites and accredits independent certification bodies that regularly monitor compliance with standards and the traceability of the certified forest products along the entire chain of custody. In 2005, 68 million hectares of the world's forests were certified according to FSC based standards. This area accounted for 1.7% of the world's total forest area, with much higher shares in Northern America and Europe; in Africa, in 2005 it did not even equal half of the continent's average yearly forest losses (cf. table 1). According to the latest data available in 2008 102.5 million hectares of forestland were FSC-certified, still most of it in Europe and Northern America (almost 82% of worldwide FSC-certified area) despite a stronger relative increase in Africa which now accounts for 3.5 million hectares or 3.4% of FSC-certified area (cf. FSC, 2008).

Table 1. Changes in forest area, forest area and FSC [a] certified area by region, 2005

Region	Annual change of forest area [b] 1990 - 2000	Annual change of forest area [b] 2000 - 2005	Forest area, 2005 (in 1 000 ha) (I) Total area [c]	Forest area, 2005 (in 1 000 ha) (II) FSC area [d]	FSC share of the total forest area (II)/(I)
Africa	–0.64 %	–0.62 %	635 412	1 732	0.27 %
Asia	–0.14 %	+0.18 %	571 577	1 091 [e]	0.19 %
Oceania	–0.21 %	–0.17 %	206 254	1 265 [f]	0.61 %
South America	–0.44 %	–0.50 %	831 540	6 546 [g]	0.79 %
North and Central America	–0.05 %	–0.05 %	705 849	22 463 [h]	3.18 %
Europe	+0.09 %	+0.07 %	1 001 394	35 028	3.50 %
World	**–0.22 %**	**–0.18 %**	**3 952 025**	**68 125**	**1.72 %**

[a] Forest Stewardship Council. - [b] FAO, 2005: 20. - [c] FAO, 2005: 18. - [d] FSC certified area calculations are based on UNEP-WCMC et al., 2006. - [e] Certified area for Asia-Pacific without Australia, New Zealand, Papua New Guinea and Solomon Islands. - [f] Certified area for Australia, New Zealand, Papua New Guinea and Solomon Islands. - [g] Certified area for Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela. - [h] Certified area for Belize, Canada, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama and USA.

3.1 Empirical evidence against the background of model conclusions (C.1) to (C.3)

Will the share of FSC certified forest land *lastingly* increase in the long run? For a given set of supply and demand functions this can only happen if the two wood markets in figure 1 are not yet balanced, i.e., as long as the difference $P_S - C_S$ still exceeds $P_M - C_M + \Delta$ for a significant number of sites. It cannot easily be assessed how far away the current situation is from the corresponding equilibrium where the 'No-Milking Condition' (1c) just holds.

In principle, one way to answer this question would be to approximate for specific forest sites the right hand side of inequality (1b). First, the extra costs $C_S - C_M$ must be estimated, second, these extra costs should be multiplied by an adequate factor $(1+d/w)$, and then this value should be compared with the price premium ΔP actually obtained in the market. Due to the positive coefficient $\alpha - 1$, this calculated value, in the strict sense, will still be less than the necessary premium. Only when the premium actually obtained exceeds the estimated necessary premium will the respective certified area be able to increase further in the long run.

On average, MURRAY and ABT (2001) estimated moderate compensating price premiums for twenty-five regions in the south-eastern USA. However, these premiums strongly differ depending on ecological constraints, the type of forest ownership, the forest site and the amount of forest land to be certified. Also, for forests in the United States, TAGGART (2000) calculated that a range of price premiums between 33% and 210% of stumpage prices was necessary to cover direct and indirect certification costs, when the timber harvest was to be reduced by 25% in order to make it sustainable. ERIKSSON, SALLNÄS and STÅHL (2007), in order to induce the short-term wood harvest of the reference situation, simulated a 17% price level increase that would be necessary after a hypothetical adoption of FSC standards for the entire Swedish forest land. As similar calculations for tropical forest sites are not available, and since assumptions concerning the ratio d/w have to be made anyway, we may rely on some qualitative considerations based on the observed share of certified tropical forests.

In African countries with exclusively tropical forests, only a few certificates have been awarded, along with an extremely low share of FSC certified area (0.05%, cf. table 2). Given conclusions (C.1) and (C.2) above, this result was to be expected, since extra costs $C_S - C_M$ are high in politically unstable countries like the Democratic Republic of Congo (cf. COUNSELL, 2006: 7ff.). Even if in the future the FSC endorsed area increased, the premium necessary for ongoing indirect enforcement will be important as long as a huge ratio d/w (cf. conclusion (C.3)) resulting from weak institutions in many parts of tropical Africa makes contract breaches profitable. It should also be noted that the African certified forest area has recently been decreasing for the reason that certificates were not being renewed due to "mismanagement or other problems" (KRAXNER et al., 2006: 101). Hence, the negative impact of consequences (C.1) to (C.3) seems to be relevant here. Unfortunately, the corresponding countries are just those for which indirect enforcement by means of valuable reputation is thought to replace direct enforcement by legal measures.

The hypothesis that the overall institutional context has a particular effect on the implementation of forestry certification was confirmed by the results of a regression analysis for a 1999 sample of about one hundred countries (VAN KOOTEN et al., 2005: 861ff.): there was a significant

Table 2. Total forest area and FSC certified area, shares of fuelwood and shares of wood exports for African tropical countries

Countries [a]	Annual change of the forest area [b] 1990 - 2000	Annual change of the forest area [b] 2000 - 2005	Forest area, 2005 (in 1 000 ha) (I) Total area [b]	(II) FSC area [c]	Share (II)/(I)	Share of fuelwood in wood removal 2005 [d]	Share of exports in production 2000 [e]
Africa	*-0.64%*	*-0.62%*	*635 412*	*1 732*	*0.27%*	–	*1.43%*
South Africa (23)	0.0 %	0.0 %	9 203	1 426	14.5%	1.4 %	1.50%
Swaziland (1)	0.9 %	0.9 %	541	17	3.14%	62.9 %	0.00%
African countries with exclusively tropical forest [f]	–	–	*617 679*	*288.9*	*0.05%*	–	–
thereof							
Cameroon (1)	-0.9 %	-1.0 %	21 245	42.0	0.20%	83.8 %	9.25%
Dem. Rep. of Congo (0)	-0.4 %	-0.2 %	133 610	0.0	0.00%	94.9 %	0.06%
Kenya (1)	-0.3 %	-0.3 %	3 522	1.8	0.05%	91.0 %	0.01%
Namibia (2)	-0.9 %	-0.9 %	7 661	82.6	1.08%	–	–
Uganda (2)	-1.9 %	-2.2 %	3 627	35.0	0.96%	90.5 %	0.00%
Zimbabwe (4)	-1.5 %	-1.7 %	17 540	127.5	0.73%	89.8 %	1.50%

– insufficient data. - [a] In brackets: number of certificates according to UNEP-WCMC et al., 2006; besides the countries mentioned in the table at that time no other African countries had forests endorsed by the Forest Stewardship Council (FSC). - [b] FAO, 2005: 196f. - [c] According to UNEP-WCMC et al., 2006. - [d] Calculated based on FAO, 2005: 280f. - [e] Calculated based on FAO, 2003b: 140f. (production and exports in 2000 except pulp for paper, paper and paperboard). - [f] Countries according to the list of forest types in FAO, 2003b: 136 (plus the forest area of British Indian Ocean Territory and Mayotte).

positive relationship between the share of certified forest land and an index increasing with a national economy's proportion of goods allocated via markets. This index, which was the lowest for the Democratic Republic of Congo (0.00) and the highest for New Zealand (9.25), was taken as one proxy variable for a sound institutional environment.

3.2 Empirical evidence against the background of model conclusions (C.4) to (C.5)

Understanding whether important premiums for big wood quantities may be *obtained* in the long run requires the consideration of the *demand* for certified wood. Again, prospects are bleak because according to market surveys, people in Europe, North America and New Zealand, on average, are not willing to pay considerable premiums; those willing to pay merely accepted mark-ups up to about 25% (RAMETSTEINER, 2000: 111f.). According to ATYI and SIMULA (2002: 17), market development for certified products is "constrained by limited demand, lack of supply, lack of premiums, and limited industry involvement." A case study on Bolivia indicated that higher "prices, in the range of 5-51%, were paid for the majority of exported certified timber products" (NEBEL et al., 2005: 175), whereas a recent Finnish study showed that most certified firms in the wood industry could not charge a price premium (OWARI et al., 2006).

If 20% of the tropical-timber markets in Europe and 10% of the markets in North America were supplied with certified wood, and if "it is assumed that annual sustainable harvest is about 1 m3 per hectare, [the corresponding 1995] demand could be satisfied by 2.3 million hectares of certified forests" (RAMETSTEINER, 2000: 145f.). This is significantly less than the FSC endorsed area of the southern hemisphere in 2005 (cf. table 1).

Even more importantly, in most African countries only relatively small quantities of wood are exported, whereas fuel wood accounts for by far the largest amount of wood removal (cf. table 2). Hence, the demand of developed countries for certified wood products cannot play a major role in overall tropical wood consumption. Also, the recent increase of the number of certificates in Asia and South America can be explained, except for Japan, by exports to Europe and North America, whereas the corresponding domestic markets "have not yet demanded certified products" (KRAXNER et al., 2006: 104).

All in all, overall demand of certified wood seems to be relatively low which means that a sufficient gap $P_S - C_S$ can only be obtained for small sustainably produced quantities (cf. conclusion (C.5) and figure 1). Consequently, sufficient premiums for *large* tropical wood quantities are not likely to be reached in the long run, especially when a future increase in wood scarcity will result in even higher necessary mark-ups (cf. conclusion (C.4)).

Thus, based on considerations of the above model and on the available empirical evidence, for the future, we can expect only low shares of certified forest areas in insecure tropical countries.

4. Discussion

As every economic model, the model outlined in chapter 2 is based on several simplifying assumptions. One such assumption is that a cheating supplier who was detected will be forever excluded from the certification scheme. Accounting for the possibility to return to the scheme after a certain time would make the net present value when cheating ($NPVV_\infty$) and hence inequality (1) even more complicated. The corresponding analysis is beyond the scope of this article. However, it is obvious that a possible return to the scheme makes cheating more profitable as $NPVV_\infty$ increases because of higher future expected rents. Consequently, we suppose that then the premium needed to indirectly enforce the considered standards needs to be greater. In contrast, risk-averse behaviour of opportunistic suppliers would make cheating ceteris paribus less profitable because then a risk premium would have to be subtracted from $NPVV_\infty$.

The analysis of a partial market model which accounts for opportunistic behaviour suggests that via the mechanism of 'Self-Enforcing Contracts', certification can only assure sustainable resource use when production takes place under relatively stable political conditions. Then, on the one hand, the costs of the 'robber economy' are elevated because of both existing legal standards and good law enforcement. On the other hand, due to overall legal security, resource owners' discount rates are relatively low, while the probability of being detected when not complying is high. Under such conditions, fraud does not pay. In such an environment, however, there is hardly any need for indirect enforcement by means of valuable reputation, since there are other, even stronger institutions that will enforce well managed resource use. A paradox occurs: indirect standard enforcement, which was thought to replace direct enforcement in cases where the legal system is poor, only works when the legal system is fairly good. Unfortunately, for opportunistic suppliers honesty is only the best policy in a tolerably 'honest world'.

Hence, when the overall institutional framework is inadequate in a way that claims are rather difficult to prosecute, then simply relying on market forces will also be inappropriate. The "creation of markets for environmental services is necessary but not sufficient for sustainable forest management […]" (KANT and BERRY, 2005: 11) and "[…] markets are only one category of institutions and cannot work efficiently in the absence of other supporting institutions" (l.c.; for a far-reaching discussion of this point cf. FURUBOTN and RICHTER: 292ff.).

Moreover, certification will best assure a sustainable resource harvest when the resource in question is not yet in extremely short supply, the consumers are well informed, and they act unselfishly. Compared to premium food, the mechanism of 'Self-Enforcing Contracts' is usually less effective, since the desired environmental process qualities are immaterial credence qualities featuring the character of public goods, so that free riders can enjoy the external benefits related to the purchase of certified forest products by other consumers. According to ERIKSSON (2003: 291), who did a game theoretical analysis of "green consumerism", it "seems that a modest degree of idealism cannot replace environmental legislation".

Of course, in those (restricted) cases where a price premium is actually reached, certification is most welcome, since it helps local people to earn their livelihood in a sustainable way (cf. CAVIGLIA-HARRIS et al., 2003: 131). Seen from a global perspective, however, this is not sufficient. There is strong evidence suggesting that markets for certified products alone cannot effectively ensure the preservation of natural resource bases. The capability of certification to enforce indirectly sustainable resource use is strictly limited, since here the relevant reputation effects rely on the existence of a large majority of unselfish 'eco-consumers' *and* on a strong institutional framework. Certification will fail when free riders are supposed to remunerate potential cheaters.

As the example of tropical forestry shows, overuse and degradation can hardly be stopped by means of certification. Institutions other than markets should be the primary means for governing how scarce natural resources are used. Instead of relying upon timber market forces, it is much more important to reduce malpractice, corruption and illegal logging through improved forest legislation and governance structures. In regards to developed countries, it is also useful to grant specific development aid that will create institutions and income sources which can prevent exhaustive resource use. This makes also sure that all wealthy citizens who benefit from positive forest externalities will contribute to forest preservation, not only those willing to buy labelled products.

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