

Sustainability and Market Structure in Renewable Natural Resource Markets: The Case of Gaharu in Papua New Guinea

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This paper considers the current state of the gaharu market in Papua New Guinea (PNG). It can be roughly characterized as a monopsony market in which a foreign intermediary buys up the harvest of gaharu from a number of villages, which it then in turn sells on the international market. We consider the impact of the current market structure on sustainability of the gaharu market in PNG and the income of the villages. It is difficult to reach firm conclusions given the huge amount of uncertainty about the stock, growth rate and rate of extraction. From a theoretical perspective, a monopsony market structure can act to protect the resource as the monopsonist restricts the amount harvested so as to reduce the price it must pay to the the villages. It could be argued, however, that this is achieved at the expense of exploitation of the villages. Also, it seems likely that the current rate of extraction even under monopsony exceeds the sustainable rate. Sustainability is further improved if the monopsonist feels its posi-

tion is secure, and hence seeks to maximize its discounted stream of future profits rather than instantaneous profits. Given the precariousness of property rights in PNG, it is highly unlikely that the monopsonist will take such a longer term view. The government in PNG and non-governmental organizations (NGOs) are keen to improve sustainability and reduce exploitation of villages by foreign intermediaries. Achieving both these goals simultaneously will not be easy. We consider the likely impact of the government taking over the role of the intermediary, breaking up the monopsony, imposing quotas or tariffs, and encouraging the villages to trade directly on the international market. It is important that the analysis of such policy initiatives is framed in a realistic context that takes account of the high level of corruption in PNG. Any kind of government intervention is likely to stimulate bribes and smuggling. There are also concerns about how the funds earned are affecting the social structure in villages, as villagers abandon traditional occupations to participate in gaharu harvesting, and use the proceeds to buy beer and spam. (*JEL* H23, L13, Q21, Q23)

KEYWORDS: Monopsony; Renewable Natural Resource; Sustainability; Regulation; Income Distribution; Corruption

1. Introduction

Gaharu is a resinous, fragrant wood product. It is thought to result from the contamination of particular species of trees by a combination of wounding and fungal infection. Gaharu¹ has been traded for thousands of years for its aromatic properties and is used in traditional medicine, religious and cultural ceremonies. The trade has connected centers of market demand in the Middle East and East Asia with the gaharu range states beginning in India and extending eastwards to Papua New Guinea (PNG). Due to the depletion of the resource in some traditional countries of production, the pressures to harvest in newly discovered resource pools such as PNG are high.

The trade in gaharu has grown rapidly in PNG since it started in 1997. It is now the main source of income for many people in remote communities. The exploitation of the resource is not subject to any form of regulation and there are concerns about the sustainability of the trade. The distribution of the resource rent is another concern, with the producers thought to be missing out. It is in response to these concerns that the World Wildlife Fund (WWF) South Pacific Program and TRAFFIC International asked one of the authors to look at the dynamics linking the market structure, the capture of the resource rent and the conservation of the resource. The present paper, although stylizing some of the facts, builds on the information collected during a three week field trip (see Gerber, 2003, and Zich and Compton, 2001).

The market can be summarized as a large group of producers (the village clans, traditional landowners in PNG) and a small number of intermediaries who export the gaharu to the international market. The data available from the PNG National Forest Authority (PNGFA) focuses on the official exports of gaharu starting in 1999.² There are no official figures on rates of harvest. Numerous interviews with villagers in seven

¹Also called agarwood, aloeswood or eaglewood. The term gaharu is used predominantly in the natives' conversations in PNG and hence will be used throughout this paper.

²The data used by the authors in this paper consists of two data sets provided by the PNGFA. The first one gives an account of all the official gaharu exports between the start of 1999 and the end of June 2004. It shows the exact date, total quantity and total value (US\$) of each gaharu export, with mention of the export company. The second data set consists of the detailed composition of each export permit, between September 20, 2001, and the end of June 2004. It provides the quantity per grade

production areas were conducted and remain the only information available on the supply side. For the present paper, this information can be summarized by saying that the production of gaharu is reasonably uniform throughout the different villages both in terms of effort and remuneration. We assume here that gaharu is a uniform good. In fact different qualities exist and command different prices. The quality of the good, however, can only be identified *ex post* and is somewhat subjective. The variation in the reported value per kilogram of the official exports since 2002 is not reliable since the amount of tax payable on exports depends on the reported quality of the gaharu. This has caused a systematic decrease in reported quality (see Gerber, 2003).³

In the coming sections, we base our analysis around the three major factors that distinguish the market for gaharu in PNG to most markets for renewable resources, even to gaharu markets in the other production states. Firstly, the trade in PNG is characterized by the fact that it does not present a case of common ownership of the resource, unlike the other gaharu producing states. Secondly, the two groups of players involved in the trade in PNG have shown remarkable short-sightedness, a condition unlikely to improve even under different market structures within the country. Only a combination of long term societal and cultural changes and appropriate trade regulation might succeed in addressing such myopic behaviors. Finally, PNG gaharu producers would remain price takers on the international markets, even if they formed their own cartel and by-passed the export intermediaries.

2. The Case of Monopsony

of each export, the selling price (US\$) per kilogram for each grade for each export, the denomination of each grade and the name of the export company. Both data sets can be obtained upon request. A summary of the first data set is provided in the appendix (Table 1, showing the quarterly exports (quantity and value) between 1999 and June 200).

³Official data showing the exports differentiated per quality and mentioning the export price of each quality was only made available for the period October 2001- June 2003. The data is split in six quarters, the first quarter is the reference. The second quarter (January-March 02) is the transition quarter during which an export levy (10% of total value) was implemented. Results are shown in Table 2 in the appendix.

Gaharu is harvested by a number of villages. Each village pools its harvest and then sells it to an intermediary. It is assumed here that there is only one intermediary that buys up all the gaharu from all the villages. Although there are in fact a small number of intermediaries active in PNG (the main players are A & F Forest Products, Eaglewood and L & T Forest Products), there is evidence of collusion through price fixing between them.⁴ Collectively, therefore, they behave like a monopsonist. The intermediary, it is assumed, faces the following inverse supply curve:⁵

$$P(t) = \frac{\alpha + \beta Q(t)}{[1 + S(t)]^\gamma}, \quad (1)$$

where $P(t)$ denotes the price at which the intermediary buys the gaharu from the villages, $Q(t)$ denotes the quantity of gaharu purchased, $S(t)$ denotes the remaining stock of gaharu, and α , β and γ denote nonnegative parameters.⁶ The industry is subject to a stock effect. That is, as the stock of gaharu diminishes the cost of harvesting rises. As a result, the price the intermediary must pay to the villages also rises. Generally, villages do not accumulate stockpiles of gaharu. Whatever is harvested is sold immediately to the intermediary. One explanation is that the quality of the gaharu deteriorates over time unless stored in the right (i.e., dry) conditions.

The intermediary then sells the gaharu on the international market. To simplify

⁴In February 2002, the PNGFA circulated an indicative price list for the five official grades exported from PNG: Super A, 2000 PGK/kg; A, 1500 PGK/kg; B, 1000 PGK/kg; C, 500 PGK/kg; D, 50 PGK/kg (in 2002, 1 PGK \simeq 0.25 USD). Producers stated that those prices were loosely or even not implemented. Many producers of the mountainous regions of the PNG-Indonesia border are still engaging in risky smuggling operations. They claim to receive higher prices in West Papua, where there is a large number of intermediaries. Although direct comparisons of prices paid to producers between PNG and West Papua are difficult (not the same classification of grades), this reinforces the idea that collusion at the intermediary level in PNG is keeping the producers' prices down.

⁵It is shown in the next section that, given the cost functions faced by the villages, this implies that each village maximizes its instantaneous profit rather than its present discounted value of future profits.

⁶To simplify the notation, whenever possible, time arguments will be suppressed.

the analysis, it is assumed that the intermediary is a price taker on the international market. Again this assumption is not that unreasonable given that PNG is a small player on the international gaharu market.⁷ The profit earned by the intermediary is determined as follows:

$$\Pi = \left[X - k - \frac{\alpha + \beta Q}{(1 + S)^\gamma} \right] Q, \quad (2)$$

where X denotes the price at which the intermediary sells the gaharu on the international market. To simplify matters it is assumed that the intermediary has a constant marginal cost of k .

The natural growth rate of gaharu is denoted by $G(S)$. It is assumed that the intermediary is myopic and simply maximizes profits each period. Such an approach is not unrealistic since each period there is a risk that the PNG government will intervene and the intermediary will lose its monopsony status or that the members of the cartel will cease to collude.

Our particular focus of interest is the impact of market structure on the remaining stock of gaharu. It is easily verified that the instantaneous profit maximizing level of Q is given by

$$Q^* = \frac{(1 + S)^\gamma (X - k) - \alpha}{2\beta}. \quad (3)$$

Therefore, the stock will rise over time until $Q = G(S)$ if $Q(0)^* \leq G[S(0)]$. Suppose instead that $Q(0)^* > G[S(0)]$. Anecdotal evidence suggests that this situation is the one that applies to the gaharu market in PNG. If $Q(0)^* \geq G[S(0)]$, then the stock S will fall over time, as will Q^* as a result of the stock effect. In the absence of a stock

⁷The two main markets for gaharu are Taiwan and Singapore. Over the period 1993-1998, Taiwan imported 4455 tons of gaharu. Main contributors (as exporters or re-exporters) were Indonesia (60%), Vietnam (12%), Thailand (7%), Cambodia (7%) and Malaysia (4%). Singapore exported and re-exported 1113 tons of gaharu originating from the *Aquilaria malaccensis* species alone over the period 1995-1997. In calendar years, PNG official exports are: 1 ton in 1999, 2.6 tons in 2000, 10.5 tons in 2001, 9.4 tons in 2002 and 12.1 tons in 2003. See Barden et al. (2000) for more details on the international markets.

effect, the stock would eventually fall to zero. The presence of a stock effect makes the dynamics more complicated. Suppose the growth function has the following quadratic form:⁸

$$G(S) = S \left(\frac{S_{max} - S}{2} \right).$$

For many cases of natural resources, we would need to consider a minimum level of stock S_{min} below which the resource is doomed to extinction. For gaharu though, S_{min} is likely to tend to zero since trees produce many seeds.⁹ The market will converge to an equilibrium where $Q^* = G(S)$. Some examples of the dynamics are graphed in Figures 1 to 3 (Appendix). In the three cases drawn, $0 < \gamma < 1$. The three equilibria situation cannot be observed if $\gamma > 1$ or if $S_{min} > 0$.

3. Breaking Up the Monopsony

Suppose that each village has reasonably well defined *de facto* property rights,¹⁰ and that the government breaks up the monopsony so that each village can trade directly on the international market. It is assumed here that each village owns an equal share of the initial stock $S(0)$ (i.e., $S(0)_i = S(0)/N$).

⁸Despite substantial scientific efforts, the growth of the gaharu itself inside the host tree is not well understood. However, the stock of gaharu is obviously related to the number of potential host trees. Furthermore, older trees seem to produce better quality gaharu (more "mature" gaharu and larger pieces; see Zich and Compton, 2001). This suggests that using the stock growth of the trees as a proxy for the stock growth of gaharu is reasonable.

⁹So far, the only gaharu producing species officially recognized as such in PNG is *Gyrinops ledermannii*. The tree produces hundreds of flowers, each of them potentially producing one fruit and each fruit containing at least two seeds.

¹⁰This is a feature of PNG, where clan ownership is not disputed. In other gaharu producing states, gaharu harvesters compete for the open access resource, quickly depleting the states' forests. In Indonesia, intermediaries sometimes fly harvesters into the national parks by helicopters (Barden et al., 2000). For a detailed discussion on property rights and natural resources see Schlager and Ostrom (1992).

Each village faces the following cost function:

$$c(Q_i) = \frac{aQ_i + bQ_i^2}{(1 + S_i/A_i)^\gamma},$$

where A_i denotes the area of land owned by village i . Here we normalize the total area to 1, i.e., $\sum_{i=1}^N A_i = 1$. Assuming that all villages own the same amount of land, it follows that $A_i = 1/N$ for all i .

Each village is assumed to maximize instantaneous profits. This assumption can again be justified by the large amount of uncertainty. Also, the remote gaharu producing communities in PNG are not renowned for taking a long-term view with regard to economic activities. For example, a significant proportion of the profits earned from the gaharu trade are spent on pure consumption goods (e.g. alcohol).¹¹ The profit for each village is

$$\Pi_i = \left[XQ_i - \frac{aQ_i + bQ_i^2}{(1 + NS_i)^\gamma} \right],$$

where $a, b > 0$. Solving for Q_i we obtain the following:

$$Q_i^* = \frac{X(1 + NS_i)^\gamma - a}{2b}.$$

Total output is obtained by summing across the N villages.

$$\hat{Q} = \sum_{i=1}^N Q_i^* = \frac{XN(1 + S)^\gamma - aN}{2b} \quad (4)$$

Rearranging, the following inverse supply curve is obtained:

$$X = \frac{2b\hat{Q} + aN}{N(1 + S)^\gamma}.$$

¹¹Several reasons might explain the short term view adopted by the producers. Firstly, these communities are traditionally made of hunters and gatherers, leading to somewhat opportunistic behaviors. Agriculture plays a very minor role, with land mostly unsuitable for any crops. Secondly, the short life expectancy (PNG average: 64 years) of those remote communities does not promote long-sightedness. One of the communities visited had lost half its male members to a disease in less than a year.

The short term view adopted by the producers is certainly reflected in their "going to the ATM" expression used to describe a gaharu harvesting expedition.

Suppose the international market price faced by villages trading on the international market falls to the level P previously charged by the monopsonist. Then the aggregate supply curve of the N villages should be the same as the supply curve faced by the monopsonist when the international price is X . Therefore, referring back to equation (1) we obtain that $\alpha = a$ and $\beta = 2b/N$. Hence we can rewrite \hat{Q} and Q^* as follows:

$$\hat{Q} = \frac{X(1+S)^\gamma - \alpha}{\beta}, \quad (5)$$

$$Q^* = \frac{N(1+S)^\gamma(X-k) - aN}{4b}. \quad (6)$$

A comparison of (3) and (5) or (4) and (6) reveals that $\hat{Q} = 2Q^*$ when $k = 0$. When $k > 0$, $\hat{Q} > 2Q^*$. In equilibrium, it must be the case that $\hat{Q} = G(S)$ at a lower level of S than under the monopsony as shown in Figure 4 (Appendix).

Suppose instead that the villages form a cartel and agree to harvest equal amounts and maximize the joint present discounted value of future profits. The instantaneous profit maximizing level of output for all the villages combined again equals \hat{Q} . This is because the villages are price takers on the international market. If instead the international demand curve is downward sloping, then the optimal output would be lower than \hat{Q} .

The Crutchfield and Pontecorvo (1969) conjecture states that a monopsonistic intermediary can control a competitive open access harvesting sector and ensure that extraction rates are efficient. Schworm (1983) describes efficiency in this case as having extraction rates identical to those of an optimizing single-owner of the resource. Schworm also derived the conditions under which the conjecture is true. The conditions are that there must be a large number of competing harvesters with identical convex technologies. Finally, Schworm expressed the sufficient conditions under which the monopsonist's stationary state of the resource stock is larger than that of a single firm (which in turn is larger than that of a competitive open access harvesting sector without monopsonistic control). The conditions are that there are no static externalities and that the harvesting costs are strictly convex and can be expressed in terms of the harvest to stock ratio.

Clearly, in the present paper we do not have static (crowding) externality, as the harvest of each producer is independent of the harvest of the other producers. The dynamic externality is present, though, throughout the inclusion of a stock effect. The cost function for each producer is strictly convex and can be expressed as a function of the harvest-stock ratio $\frac{Q}{S}$. Schworm's results thus suggest that if the monopsonist and the producers were adopting a long term view, we should have a stationary state for S larger than under the single firm scenario (which in our case is identical to the aggregation of the N individual producers under a well defined property rights system). Our results under the short term behavior assumption for both the monopsony and the individual producers seem to go in the same direction: the instantaneous profit maximizing level of harvest is lower under the monopsony than under the single firm scenario. However, that does not say anything about the steady state values of the stock, but only that these values (below or above the sustainable level) would be reached faster under the single firm structure than under the monopsonistic structure.

4. Distributional Issues

The Government should be concerned about the share of total profits received by the villages as well as the stock level of gaharu. The profits of each village i under the monopsony regime (assuming the monopsonist profit maximizes) is

$$\Pi_i = \frac{[(X - k)(1 + S)^\gamma - a]^2}{16b(1 + S)^\gamma}. \quad (7)$$

If each village sells directly onto the international market, profit is

$$\Pi_i = \frac{[X(1 + S)^\gamma - a]^2}{4b(1 + S)^\gamma}. \quad (8)$$

A comparison of (7) and (8) reveals that when $k = 0$ profits for each village are four times higher when they sell directly on the international market rather than to the intermediary. Profits differ by more than a factor of four when $k > 0$.

These results clearly illustrate the conflict between sustainability and distributional issues. The monopsony market structure acts to protect to some extent the resource

stock. However, this is achieved at the expense of the villages that earn much lower profits as a result. The profits earned by the intermediaries are repatriated to the monopsonist's home country (e.g. Singapore or Malaysia). Nevertheless, income levels have risen significantly in many villages since the start of the gaharu trade. During interviews with one of the authors, producers from the East Sepik region stated that cash income increased from 200-700 PGK per year per household, selling mostly carvings and crocodile skins, to 1000-3000 PGK per year per household since the start of the gaharu trade. In the remote areas of the Sandaun province (west Sepik), producers often didn't have any cash income at all until they traded gaharu, now earning between 700 and 1500 PGK per year.

As well as the distribution of income, NGOs and government officials are concerned about the use of the newly found cash income in the villages. Ideally, a large share of the gaharu income should be invested in housing, equipment and tools, such as portable sawmills and boat engines, health, and schools.¹² However, as was reported during the interviews, the gaharu income is spent mostly on pure consumption goods. Food that used to be hunted, gathered or cultivated is now often replaced by rice and tinned fish or meat. Consumption of soft drinks has increased dramatically, with the associated effects of a non-customary consumption of sugar. With a biased intra-family distribution of the income towards the man, a large share of the money is wasted on alcohol as well, creating new social problems within the communities.

Solutions need to be found to decrease the waste of the resource rent within the communities. With regard to the problem of corruption discussed in the next section, it seems preferable to have organizations closer to the communities looking after the distribution of the resource rent. A solution is proposed later in the paper.

5. Mechanisms to Regulate the Stock and Distribution of Income

¹²Indeed, the PNGFA sent young forestry graduates in remote areas to develop sustainable logging programs using portable sawmills, the latter purchased by the communities themselves. Programs aimed at the collection of rain water are also sponsored by NGOs, to prevent the consumption of contaminated water from the rivers, in exchange for signing a charter on the sustainable use of the clans' forest.

(i) *Quotas*

Quotas, in theory, provide a straightforward way of ensuring that the stock of gaharu is kept at a desired level. If the maximum quota for the monopsonist is set equal to $G[S(0)]$, this guarantees that the stock will not decrease over time. Of course, the Government may decide that the initial stock $S(0)$ is either too high or too low, in which case the quotas can be adjusted accordingly.

There are three main problems with the implementation of such a system. First, it is far from certain that the Government is able to observe $S(0)$, let alone $G[S(0)]$.¹³ Second, even if the Government can observe $G(S_0)$, is it also able to observe the quantity Q of gaharu actually harvested? Third, even if it observes $G[S(0)]$ and Q , is it able to enforce its will on the intermediary? The risk exists that the intermediary will circumvent a quota by a few well placed bribes of government officials. These issues are discussed in greater detail in section 6.

(ii) *Taxes*

The impact of a tax τ on the monopsonist's instantaneous profits is as follows:

$$\Pi = \left[X - k - \tau - \frac{\alpha + \beta Q}{(1 + S)^\gamma} \right] Q.$$

This means that the instantaneous profit maximizing level of output is now

$$\tilde{Q} = \frac{(1 + S)^\gamma (X - k - \tau) - \alpha}{2\beta}.$$

If τ is set at a sufficiently high level, it will be possible to ensure that $\tilde{Q}(0) \leq G[S(0)]$, thus guaranteeing that the stock of gaharu increases. If even after the imposition of the tax it is still the case that $\tilde{Q}(0) > G[S(0)]$, then the tax will act to increase the level of S to which the system converges.

As with quotas, implementing the tax is not necessarily straightforward. It is not clear that the Government has enough information to set τ at the appropriate level.

¹³A current joint project of the CSIRO and WWF has produced a map of the potential distribution in PNG of the gaharu producing species based on several geographical and biological criteria. The map has already proved reasonably accurate.

Also, it may not be possible to observe Q , and then enforce payment of the tax on the intermediary. This issue of monitoring and enforcement is the focus of the next section.

6. Monitoring, Enforcement and Corruption

The land in PNG is traditionally owned by the clans and divided among their families. Village and clan boundaries are defined in the oral tradition of the community. The government only intervenes in cases of disputes between clans over particular lots. This can happen when a gaharu producing area is located close to the boundary. In most cases though the ownership of the different lots is clearly defined, at least in the mind of the communities concerned. Therefore the management of the gaharu resource does not suffer from the externality problems of the open access situation.

Given that property rights are not a major concern, the main focus of attention is the monopsony itself. Two alternatives to the *status quo* would be either for the government to take over the role of intermediary itself or encourage more competition between existing intermediaries. Such policies, however, could create conflict between the two main goals of conservation and achieving a fairer distribution of the surplus. The focus of the PNG National Forest Authority (PNGFA) so far has been towards the latter, whereas non-governmental organizations (NGOs) such as the WWF are pushing the sustainability issue.¹⁴ The NGOs have significantly improved the villagers' education in terms of harvest practices. The PNGFA has circulated a list of indicative prices that villages are entitled to ask from the intermediaries. Both measures have improved the information available to the villages and their awareness of managerial issues and market oriented behaviors. The next issues to be addressed by the PNGFA, with the help of the NGOs, are how best to monitor and enforce controls over the level of production and the income received by gaharu producing communities.

Knowing that the rate of harvest at present is close to Q^* and almost certainly above the sustainable level, it is important that steps are taken to reduce the rate of harvest. The two main tools at the government's disposal for achieving a reduction in

¹⁴These issues have also been addressed by Vincent (1990) for the case of timber from tropical forests in Malaysia, and more generally by Hyde and Sedjo (1992).

Q are a regime of quotas or export taxes. Both systems suffer from similar problems. Smuggling operations undertaken by the producers are still minor compared to the official trade. This is mainly due to the difficulty of transporting large quantities through mountainous regions covered with thick forest. Groups of producers have also smuggled small quantities through the north western border (the only road between the regions of production and Western Papua) with the help of their wantok custom officers.¹⁵ An even easier road is allegedly used to smuggle larger quantities by the intermediary; smuggling using light engine boats is growing. These larger smuggling operations are a serious threat to a quota or an export tax system. At the time of the field trip, the customs officers did not have a single engine boat.

The introduction of a government-run gaharu board that would act as an intermediary and buy up all the gaharu harvested in PNG is being seriously contemplated by the PNGFA. This might increase the sustainability of usage, while at the same time ensuring that a larger share of the resource rent is returned to the villages. However, in a non-transparent market, factors such as internal market knowledge, contacts and reputation play a large role in the success of a business operation. This is precisely the type of situation faced in the international market for gaharu. Government officials and villagers in PNG at present lack such assets and it appears that replacing the intermediary is hardly feasible. This system could also worsen the problem of corruption in the administration.

The problem of corruption in PNG is pervasive. The combination of an unstable political situation and the wantok system is largely responsible. The wantok system pressures officials in the administration to favor their relatives, while the rapid rate of turnover among civil servants reinforces the urgency with which they abuse the system. This unfortunate side effect of a traditional social system when applied to a more modern society, coupled with more “usual” types of corruption (mainly bribes), means that more government intervention in the market would not necessarily be a positive

¹⁵Wantok literally means “one talk”. An indication of the strength of community bonds in PNG, it represents all the people speaking the same language, the relatives, the neighbors. A person in an official position has the moral duty to help his wantoks.

development.¹⁶

There are a few options available to the government in order to improve the share of income received by the gaharu producers. However, as mentioned above, replacing the intermediary may not be feasible. For similar reasons, it may not be possible for producers to deal directly on the international market, even though this could potentially increase their profits by more than a factor of four (see section 5). There is another way to break up the monopsony: to open up the intermediary market to other companies. The presence of competition on the intermediary market would allow the producers to increase their profits. The problem with this solution is that it could increase the total level of production to even more unsustainable levels.

The opening up of the intermediary market in combination with the introduction of a system of cooperatives formed of villages from the same wantok might help to address both the problems of distribution and sustainability. By grouping the production of several villages, record-keeping could be more centralized and more effective, and perhaps allow them to eventually access the international market directly. The cooperatives would also have better control over the prices paid by the intermediaries than individual villages bargaining on a case by case basis. This would give the villages a greater incentive to use the gaharu sustainably. The formation of small regional cooperatives seems to be supported by the villages. They have in some cases already attempted to group their production to improve their bargaining situations with the intermediary. The cooperatives could also retain a certain share of the resource rent, preventing some of the wasteful behavior of the individual producers, and invest these funds in productive, capacity building projects for the community. In order to circumvent the problem of alcoholism among the men, an emphasis could be placed in the involvement of the women within the cooperatives.

One problem associated with cooperatives is that crime is rampant in PNG. There are several accounts of thieves stealing gaharu in the villages or attacking shipments on the rivers. With an increased distance to travel with the good (intermediaries currently

¹⁶Other examples where government intervention can make matters worse are discussed by Stavins and Jaffe (1990), Deacon (1995) and Angelsen (1999).

fly into the villages), producers are more likely to be subjected to such attacks. For many producers, travelling long distances is also not logistically possible. So the scale of operation of the regional cooperatives must balance potential economies of scale and the risk factors associated with geographically larger scales of operations.

7. Conclusion

The gaharu market in PNG can be characterized as a monopsony, in which a foreign intermediary buys up all the gaharu and then sells it on the international market. This has led to concern in the PNG government and among NGOs that the villages that harvest the gaharu are being exploited by the intermediary. Cutting out the intermediary completely does not appear to be an option, since the villages do not have the necessary contacts to sell directly onto the international market. There appear, therefore, to be only two feasible alternatives to the current system. First, the PNG government could take over the role of intermediary. Second, the government could encourage more intermediaries to enter the market in the hope that this will push up prices.

The first option, i.e., nationalization of the intermediary, is not desirable given the high level of corruption in PNG. The entrance of more intermediaries into the market probably provides a more effective mechanism for increasing the incomes of the villages, particularly if villages become better informed of the true market value of gaharu. This, however, will not help improve sustainability.

A monopsony in principle can encourage more sustainable usage. However, this by itself in this case is not sufficient. Perversely, the mere act of discussing alternatives to the monopsony may encourage a faster rate of extraction by the monopsonist. Also, it is doubtful whether the government can credibly commit to granting one firm a monopsony. Hence this is not a desirable outcome either. As a result, the intermediary encouraged bad harvest practices by the villagers and kept them uninformed of the true value of the good so as to minimize its costs. Now the market structure seems to be shifting towards oligopsony, with price collusion between the oligopsonists.

Probably the best hope of achieving the twin goals of increasing the villages' share of the profits and achieving sustainability is through a combination of increased com-

petition between intermediaries, the formation of cooperatives of villages belonging to the same wantok, and the use of an export tax or quota. The introduction of transferable quotas, in particular, could provide villagers with a vested interest in preventing smuggling.

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Appendix

Quarter	Quantity (kg)	Value (US\$)
I-IV.1999*	1,011.00*	136,880.00*
I.2000	550.00	71,000.00
II.2000	360.00	59,000.00
III.2000	580.00	134,550.00
IV.2000	1,180.00	276,892.00
I.2001	2,343.00	468,680.00
II.2001	2,495.00	494,130.00
III.2001	2,473.50	308,130.00
IV.2001	2,796.75	373,745.00
I.2002	2,365.00	184,750.00
II.2002	1,734.00	88,520.00
III.2002	2,110.00	103,242.50
IV.2002	3,170.00	130,175.00
I.2003	4,520.10	211,187.00
II.2003	2,487.00	108,397.00
III.2003	1,886.90	81,138.00
IV.2003	3,214.44	118,988.70
I.2004	1,690.15	74,734.00
II.2004	1,740.90	80,660.00

Table 1: Official Quaterly Gaharu Exports in PNG (*=yearly data)

Quarter	Fisher Index
IV.2001	1
I.2002	0.485
II.2002	0.227
III.2002	0.267
IV.2002	0.347
I.2003	0.504
II.2003	0.256
III.2003	0.194
IV.2003	0.310
I.2004	0.179
II.2004	0.193

Table 2: Gaharu Exports, Fisher Quantity Index

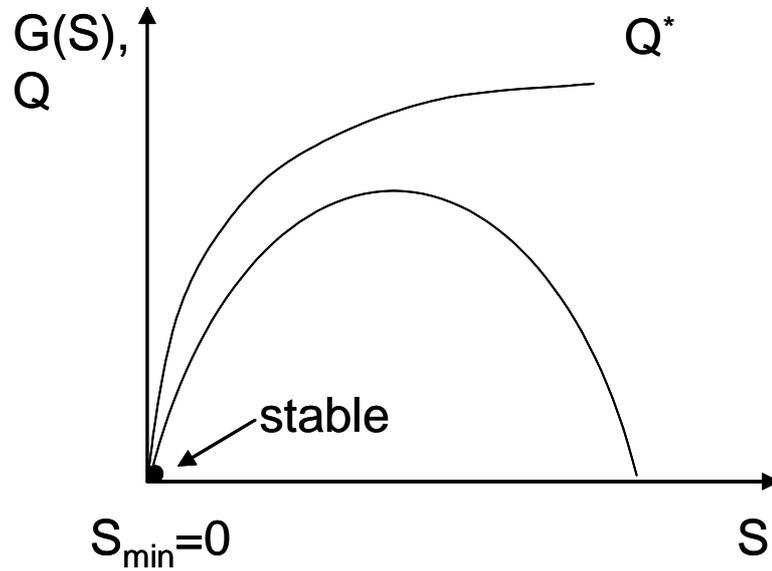


Figure 1: Single Equilibrium Situation

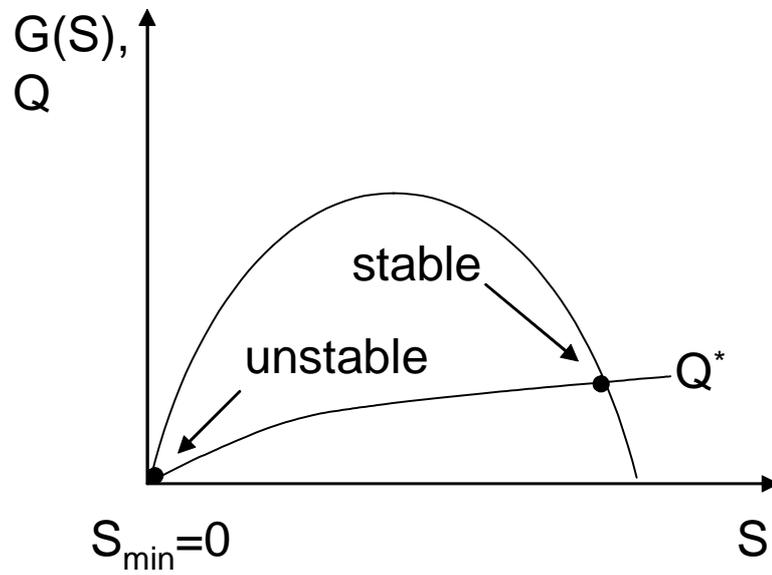


Figure 2: Two Equilibria Situation

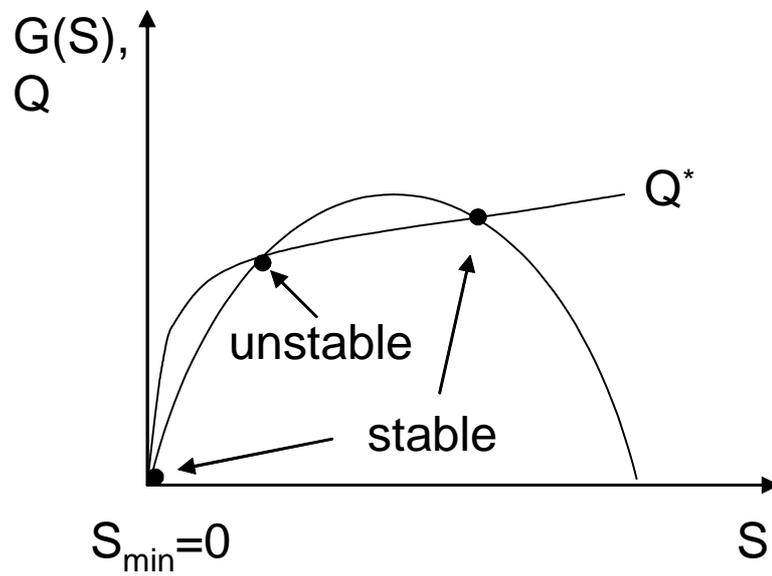


Figure 3: Three Equilibria Situation

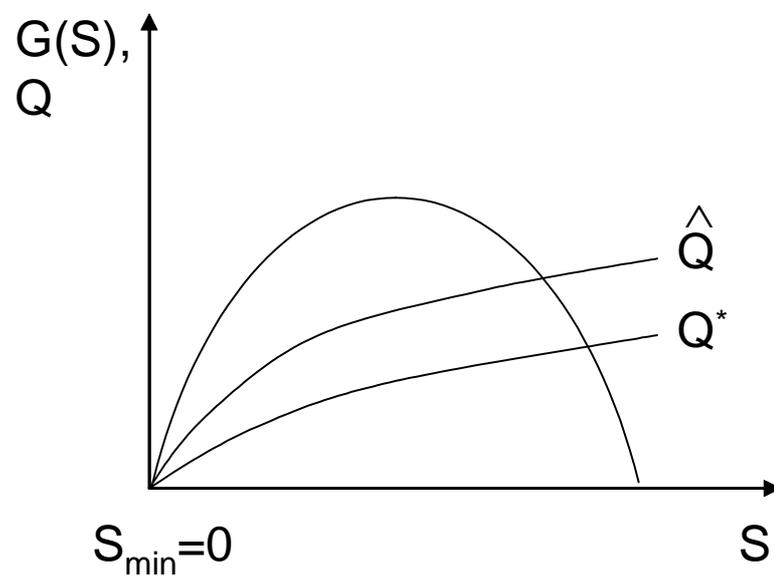


Figure 4: Equilibrium Stocks, With And Without The Monopsony