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Economic incentives for abandoning or expanding gum arabic production in Sudan

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Abstract

In this paper we use a real options approach to analyze farmers' economic incentives to abandon gum production or expand by creating new plantations. Our results indicate that agricultural crops currently provide higher economic benefits as compared to gum agroforestry. However, we show that the incentives for gum producers to abandon gum production is low, because (i) land is abundant, (ii) gum arabic is produced during the dry season and agricultural crops mainly during the wet season, and (iii) the dry season opportunity cost of labor is low. Hence, an increase in deforestation in the near future is not expected. The analysis further shows that an increase in the prices of gum arabic of about 315% is needed to induce an expansion of gum agroforestry and a shift in land use system from continuous agricultural production to gum agroforestry system. Hence, also an expansion of gum forests and/or agroforests in the near future is not expected. Price policies to improve incentives for expanding gum forests are discussed.

Keywords: Gum arabic; Deforestation; Abandonment/expansion; Real options; Sudan

1. Introduction

The gum belt in Sudan provides a natural buffer zone between the desert in the North and the more fertile agricultural lands in the South. Deforestation within the gum belt has lead to an increase in desert encroachment and threatens agricultural production (IEED/IES, 1990; Keddeman, 1994; Olsson and Ardö, 2002). Following the Sahel drought of the 1970s and 1980s a southward shifts in the tapping of gum has been reported (IIED/IES, 1990), as people moved from the more fragile environment in the northern parts of the gum belt to the less fragile and better environment of the south. Over the last three to four decades the land use practices have moved from a rotation with long fallow periods (15–20 years) of gum cultivation interspersed with short period of cultivation (4–6 years) towards a more or less continuous cultivation (Olsson and Ardö, 2002). The low and highly volatile producer prices of gum arabic over the previous decades have accelerated the gum deforestation process (Barbier, 2000).

An important question is if it can be expected that the observed deforestation of gum arabic will continue. Previous studies on gum belt deforestation show contradictory results with regard to the profitability of gum production. Ahmed (2000) estimates the financial internal rate of return of cultivating gum forest for 16 years to be around 15%. Barbier (2000) uses an economic analysis of six representative cropping systems containing gum arabic to estimate the net present value. He finds that because of a decline in the real producer price of gum arabic relative to other crops, the relative profitability of gum arabic is lower than that of other crops except in areas where field crop damage occurs frequently. But he also concludes that the inclusion of the environmental benefits of gum arabic and the role of the gum belt in controlling desertification means that its social profitability is much higher than its private profitability.

The previous studies have assumed that gum arabic production directly competes with agriculture production for labor. Agriculture production, however, mainly takes place

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during the rainy season while the harvesting of gum arabic takes place during the dry season. Furthermore labor is often considered the most important constraint to agriculture for traditional farmers in the gum belt area (Elmadih, 1992; El-Dukheri, 1997). As long as labor is relatively scarcer than land, comparing gum production in the dry season with agriculture production in the wet season can provide misleading results. In this study we analyze the incentives for abandoning gum production by comparing the benefits on the basis of the opportunity costs for labor in the various seasons.

The prices of gum arabic over the last few decades exhibit considerable fluctuation (Barbier, 2000; Elmqvist et al., 2005). The Discounted Cash Flow (DCF) technique used so far in the literature to examine the profitability of gum cultivation does not consider the fluctuation in gum prices and the uncertainty over gum return. DCF analysis assumes that either the investment opportunity is reversible or, if irreversible, is a now-or-never opportunity. As gum forests allow farmers to benefit from the trees over a number of production periods the uncertainty over gum returns, the quasi-irreversible nature of the land allocation, and the flexibility in preserving, abandoning and adopting interact to generate a real option value for planting additional gum arabic trees and for abandoning gum arabic forests (Dixit and Pindyck, 1994). These real option values can be substantial (Mithöfer et al., 2004) and ignoring them results in under estimation of abandonment and expansion costs. This paper contributes to the gum belt deforestation literature by analyzing the incentives for abandoning and expanding gum production using a real option approach.

In summary, the two main objectives of this paper are to analyze the economic incentives: first, for preserving the existing gum forest to understand if in the near future further deforestation of gum arabic can be expected and, second, for establishing new plantations at farm level to assess whether expansion of gum forest by farmers can be expected in the near future. More specifically we will answer the following research questions: first, how much do the opportunity costs of labor have to rise to induce farmers to abandon their gum forest? And second, how much do gum prices have to rise in order to induce an expansion of the area under gum forest by converting either agricultural or bare land to gum production?

The remainder of the paper is structured as follows. Section 2 presents the theoretical framework of the paper and introduces the gum production and management system. Section 3 describes the model. Expected average annual net-benefits (annuities) from gum agroforest, gum forest and permanent agriculture systems are introduced and compared to identify critical conditions for continuation and expansion of gum arabic production. Section 4 presents the data base and the parameters of the model. The expected annuities for the different systems are calculated based on the data obtained from a farm level survey. Uncertainty is considered by using Monte Carlo simulation. Secondary time series data are used for the estimation of the coefficients of the real option model. Section 5 presents and discusses the results and compares the expected annuities under uncertainty and irreversibility for the different systems with the critical values for expansion. The conclusions are drawn in the last section.

2. Theoretical framework

From the perspective of private profit maximization, economic gain is a necessary but not a sufficient condition for preserving or planting the gum trees. Expected returns from the trees depend on the value of the services the trees provide. These in turn are determined by economic and biophysical factors such as costs, output prices and growth and yield functions. As long as alternatives for allocating either land or labor exist (e.g. off-farm income), preservation and plantation of gum arabic has an opportunity cost. Also, farmers do not face a now-or-never dichotomous choice of either abandoning the gum business or planting trees as they can postpone the decision. Additionally, they face uncertainty and irreversibility about future benefits and costs. Taken together, flexibility, irreversibility, and uncertainty influences the optimal timing of the decision to abandon or expand the production of gum arabic.

2.1. The bush-fallow cycle of gum cultivation

For the purpose of exposition we will model the bush-fallow cycle of gum cultivation which prevails in west Sudan. The bush-fallow cycle is an agroforestry system based on integrating annual crops with gum trees in a temporal sequence. There are, however, other ways in which gum arabic is cultivated or combined with field crops by farmers throughout the gum belt. Other forms of gum cultivation are: the agroforestry system based on a spatial mixture – where annual crops and gum are produced from the same land unit simultaneously – and pure stand gum forest used for the production of gum only. Based on our survey data 75% of the farmers mentioned to follow the bush-fallow cycle (agroforestry based on temporal sequence) either solely or together with a combination of spatial agroforestry or pure stand gum forest. About 30% of the farmers mentioned to use spatial agroforestry either solely or in combination with the other two gums land use (Table A.1. in the Appendix shows the percentage of farmers practicing the different gum cultivation systems).

Fig. 1 illustrates the bush-fallow cycle of gum cultivation. The cycle starts by coppicing old gum trees at 10 cm from the ground surface. The land is then used for the cultivation of field crops such as millet, sesame, groundnut, sorghum, watermelon and roselle (*Hibiscus sabdariffa* L.). The average duration of field crop cultivation is around 4–6 years. Once the land is abandoned and put under fallow the coppiced trees shoot up and regenerate. Gum harvest usually starts after the tree has re-grown for 5–6 years and continues up to 15–20 years. When gum trees cease to produce they are coppiced again for crop cultivation and the cycle is repeated (Ballal, 2002). The final tree stand is mainly the result of coppice regeneration, besides some regeneration from seeds dispersed naturally and in few cases from deliberate enrichment planting. During the period of field crop cultivation the coppiced shoots re-growth is removed to allow for the establishment and growth of agricultural crops.