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Deforestation in Cameroon: immediate causes and consequences

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ABSTRACT. The effects of deforestation in Cameroon such as the erosion of agricultural lands, drying up water bodies during dry seasons, desertification, disappearance of plant and animal species, modifications of both local and regional climatic conditions and global warming through its effect on the global carbon cycle are likely to affect agricultural activities and economic growth. This paper investigates the immediate causes and consequences of deforestation in Cameroon between 1970 and 2000. Quantitative estimates show that coffee, and cocoa producer prices, food crop prices, and the timber export price index, on the one hand, and the oil boom, the structural adjustment policies, and the devaluation of the CFA franc, on the other hand, are quite important in stimulating the clearing of forests. Equally, the agricultural value added per hectare increases the profitability of maintaining forests. The implication of these results is that the importance of non-forest policies is underappreciated in Cameroon.

1. Introduction

The progressive disappearance of tropical forests constitutes one of the major environmental problems in both industrialized and developing countries. In the last 8,000 years, world forest cover declined more than 40 per cent, from 6,200 to 3,300 million hectares (Bryant *et al*., 1997). In the period 1980–1990, an estimated 137.3 million hectares of tropical forests were cleared, about 7.2 per cent of the total that existed in 1980 (FAO, 1996). New studies demonstrate a rate of forest loss considerably worse than previously known (Marcoux, 2000; FAO, 2001).

In Africa, between three and five million hectares of tropical forests disappear each year, an area greater in size than the country of Togo and larger than several European countries (FAO, 1996). Compared with other regions, Africa has been the most affected with an annual deforestation rate of 0.7 per cent (Marcoux, 2000).

However, forests play a very important role in the genesis and maintenance of the production potential of soils and watershed protection, harbor large proportions of the world's plant and animal species, and serve as a reservoir of resources in the form of food, medicinal plants, and wood. Over one half of the world's living species are found in tropical forests that only occupy 7 per cent of the total land surface (Serageldin, 1992). Unfortunately, most of these species are not found in any other type of

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ecosystem. More than three quarters of the world's population depend directly on plants for medicines, many of which are extracted from tropical forests (Serageldin, 1992).

In Cameroon, the supply of fuel wood from forests accounts for over 60 per cent of the energy consumed and has been increasing at a rate of 2.5 per cent per year since 1974–1976 (Cleaver, 1992: 65). The forestry sector occupies the first place in export tonnage and third place in foreign earnings. It accounts for about 4 per cent of the Gross Domestic Product (GDP) and offer about 40,000 jobs (Besong, 1992). Cameroon's forests contain an estimated 300 different tree species and the country can be said to have a forest-based economy (Besong, 1992). Furthermore, forests serve as a habitat for primitive populations (Pygmy). They live in and near tropical forests and are for the most part poor. It is then clear that the immediate survival of these people is threatened when and where forests are damaged through inappropriate development.

Cameroon is also one of the Sudano-Sahelian countries in Africa that shows signs of some desertification (Cleaver, 1992). It appears therefore that deforestation in Cameroon should be the preoccupation of policy makers because of its threat to ecological sustainability and to socio-economic development in the long run.

The high speed of actual forest exploitation in Cameroon accelerates degradation of forestry resources and the environment. In a total surface area of 475, 10^5 ha, forest covered an area of 280.25, 10^5 ha in 1965. This forest area dropped to 233, 10^5 ha in 1980 (World Bank, 1992). Meanwhile in 1995, the extent of Cameroon forestland came down to 195.98 10^5 ha, that is a loss of 37.02 10^5 ha (16 per cent) of forest compared with 1980. This forest-clearing process was at different rates from one period to another. Thus, between 1980 and 1985, the World Bank (1992) estimated an annual forest loss rate of 110, 10^3 ha. This rate rose to 122, 10^3 during 1980–1990, to 190, 10^3 from 1990 to 1995, and finally to 205, 10^3 ha between 1990 and 2000 (World Bank, 1995; FAO, 2001). Generally, deforestation rate estimates in Cameroon range from 80,000 to 200,000 hectares per year (Ndoye and Kaimowitz, 2000). However, Laporte *et al*. (1999) made the most serious effort to measure deforestation and found that an average of 130,000 ha of forest was cleared each year from the mid 1970s.

This accelerated rate of deforestation is facing a rather mediocre regeneration effort estimated at 1,000 ha per year (World Bank, 1995). This is why the identification of factors leading to the halting of forest disappearance has become a priority. A step toward this aspiration was recently made by revising the forest policy in order to promote sustainable use of forest resources. This has resulted in the creation of the 'Office National de Développement des Forêts (ONADEF)' in 1990 and the Ministry of Environment and Forest (MINEF) in 1992. Regulations governing the entire forestry sector have been also significantly modified with the creation in 1995 of the 'National Forestry Action Program (NFAP)'. However, the pressure on forest areas is not yet reduced, indicating the need for further investigation of the causes of deforestation. Our paper falls in line with this preoccupation and intends to put elements of economic policies at the disposal of policy makers.

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To better apprehend the negative externalities of deforestation, careful diagnoses of the causes is essential; that is of the factors that shape agents' actions, and in particular their decision to deforest. These causes can be grouped under three categories, namely the direct sources, the immediate causes, and the underlying causes of deforestation.

The underlying causes, which are macroeconomic variables, determine the immediate causes, which in turn influence the agents of deforestation (farmers, animal husbandry, loggers) who are the sources of deforestation. The immediate causes influence the decisions by the deforestation agents. According to Angelsen and Kaimowitz (1999), the mixing up of these three levels of deforestation distorts the causal relationship and often leads to serious misspecification in regression models. Furthermore, potential statistical problems of multicollinearity and biased estimates may be encountered.

This paper stands on two motivations. Firstly, as deforestation is a location-specific problem with the effect and magnitude of each identified factor differing from country to country and from one region to another, it is absolutely necessary to empirically determine the extent and the degree to which the immediate factors identified influence the progressive disappearance of forests in Cameroon. This would help in the formulation of appropriate economic and environmental policies to mitigate, if not halt the effects of unsustainable deforestation. Secondly, given that a mixing up of the various levels of factors causing deforestation leads to a wrong specification of the causal relationship between variables, this paper avoids this type of mistake by concentrating on the immediate causes of conversion of forests. This is because we expect to find a much stronger correlation between deforestation and the micro-level decision parameters, than between deforestation and macro-level variables. In addition to the immediate causes, GDP per capita will be introduced. These motivations bring us to the following questions: What are the immediate causes of deforestation in Cameroon? What are the effects of these immediate factors of deforestation and what are the magnitudes of these effects? Our paper shall be oriented towards these horizons.

The remaining part of our analysis will be centered around five points. Sections 2 and 3 present the literature review and the methodological approach respectively; section 4 deals with the empirical results; and finally section 5 covers the conclusion.

2. Literature review

2.1. Theoretical framework

The literature on the causes of accelerated clearance of tropical forests for agricultural activities relies principally on two different approaches, namely the population (subsistence) approach and the open economy (market or profit-maximizing) approach.[1] These two approaches are useful to explore

[1] However, other approaches such as the Chayanovian or the general equilibrium approach can yield hypotheses that are consistent with both approaches mentioned above.

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the range of hypotheses for the effect on deforestation of changes in economic variables.

The population and open economy approaches refer to different assumptions made about household behaviour and the labour market, the latter being the most important (Angelsen *et al*., 1999). In the population approach (PA), no labour market exists, whereas a perfect labour market is assumed in the market approach (MA), where any amount of labour can be sold and hired at a fixed wage. In our paper, the MA seems to be more appropriate because migration became very important in Cameroon after the oil-boom in 1978 (Ndoye and Kaimowitz, 2000). In addition, the population in Cameroon no longer relies on subsistence farming activities.[2]

Compared with the subsistence approach, the open economy approach has a different way of reasoning, although the key change in the underlying model assumptions is only the introduction of a labour market where labour can be sold at a fixed wage. This wage rate gives the opportunity costs of labour used in agriculture (Angelsen *et al*., 1999). The forest-clearing decisions can then be examined as a profit-maximizing problem. However, this does mean that the household's overall objective is to maximize profit. The perfect labour market assumption implies that production decisions can be separated from the consumption and labour supply of the household (Angelsen *et al*., 1999). Thus, the production decisions of a utility-maximizing household can be analysed as a profit-maximizing problem. The open economy approach does not need to introduce any particular behavioural assumption for the farm household.

2.2. Empirical review

The causes of deforestation have been attributed to several factors. The most important categories are the immediate and the underlying causes.

In Sudan, Stryker *et al*. (1989) found that increased producer prices of export crops encouraged woodland clearing for crop cultivation and this resulted in significant deforestation. Based on the market theoretical approach, Angelsen *et al*.'s (1999) statistical analysis in Tanzania showed that the increase of agricultural output prices, in particular annual crops, is a major factor behind deforestation. The results of these authors were confirmed in Ivory Coast where the effects of price increases of export goods contributed to deforestation but to a lesser extent than the lack of a consistent and secure land tenure system (Reed, 1992). Osei Asare and Obeng Asiedu (2000) found in Ghana a long-run equilibrium relationship between the producer prices of cocoa and coffee, fertilizer prices, food crop prices, agricultural wages, timber prices, and agricultural credit, on the one hand, and deforestation, on the other hand. According to the findings of these authors, higher levels of fertilizer prices, food crop prices and coffee producer prices stimulate in the long-run higher levels of deforestation

[2] After the oil boom, government investment of oil revenues in public enterprises and rapid urban population and income growth made it more attractive for farmers to grow food for urban consumers. Moreover, the oil boom accelerated rural to urban migration by stimulating the urban economy. This is why the MA is appropriate for the current study.

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whereas higher levels of agricultural wages precipitates lower levels of deforestation. Other empirical works reveal that devaluations undertaken in Ghana at the beginning of 1980s motivated forestry exploiters to intensify tree felling for more exploitation of timber and woodwork. This ended up accelerating deforestation (World Bank, 1994; Pimentel *et al*., 1991). These results were confirmed in Malawi (Cromwell and Winpenny, 1991), and in Botswana (Perrings *et al*., 1988).

Previous studies on Cameroon

Although Cameroon is the central African country that has attracted most attention from researchers and environmentalists, very few econometric studies on the causes of deforestation are available. Ndoye and Kaimowitz (2000) look at the influence of macroeconomic and agricultural policies, market fluctuations, and demographic changes on the humid forest zone of Cameroon between 1967 and 1997. To capture deforestation, they use increases in perennial crop area and in the combined area of annual crops. The results indicate that, after the oil boom, the Structural Adjustment Program (SAP) and the devaluation of the CFA franc in 1994, the net effect of cocoa, coffee and food production increased the pressure on forest areas. This paper is basically descriptive.

A study of deforestation in the area around Ndélélé in the East Province based on remote-sensing analysis points to a marked increase in deforestation after the economic crisis in the mid 1980s (Mertens *et al*., 1999). This paper uses the same proxy to capture forest clearing as in Ndoye and Kaimowitz (2000). It investigated the role of the main driving forces of deforestation at the village level through bivariate regression analyses. However, it concentrated on the underlying factors of deforestation and covered a very small part of the country territory.

The impact of SAP on forests is also addressed by Kaimowitz *et al*. (1998) using a comparative analysis between Cameroon, Bolivia, and Indonesia. The results indicate that forest clearing for food crops increased under SAP. Nkamleu *et al*. (2002) examined fuelwood consumption in households of forest zones in Cameroon. The results confirmed the importance of fuelwood as a source of energy, and the econometric analysis showed a negative correlation between income levels and fuelwood consumption. Finally, a series of papers focusing on the underlying, and social causes of deforestation confirmed the high rate of forest clearing in Cameroon and concluded with the necessity of some well-elaborated protection policies (Cleaver, 1992; Besong, 1992; Toornstra *et al*., 1994).

Compared with the studies reviewed above, our paper has three special novelties. Firstly, it explores the linkages between socio-economic variables and deforestation using long-run statistical analysis, which is the first attempt for Cameroon. The need for quantitative analysis of the immediate factors behind deforestation in Cameroon became necessary in order to determine the net effects of policies and provide more concrete policy guidelines. Secondly, data on annual forest cover are used as a proxy for deforestation. This proxy seems to craft better to the deforestation process in Cameroon than the increases in perennial crop area combined with area of annual crops used in previous papers. Although agricultural land

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expansion is a major source of deforestation, the proxy is not good at the national level for two main reasons:

1. It does not cover all sources of deforestation.
2. Some agricultural expansion may not be into forest, but, for example, grasslands and Savannah.

Thirdly our study uses the agricultural value added per hectare instead of the approximate monthly revenue of farmers used in various papers (Osei Asare and Obeng Asiedu, 2000).

2.3. Immediate factors of deforestation in Cameroon

Cash and food crop prices, timber prices, agricultural input prices, agricultural wages and credit availability to farmers have been identified as immediate causes of deforestation in Cameroon that determine the profitability of farming and logging activities. To be in a position to mitigate or halt the effects of forest clearing with relevant counter-policies, one needs to appreciate the extent to which the immediate factors propel deforestation agents to deforest.

However, one aspect often overlooked is the environmental consequences of misguided government policies on deforestation. The effects of such policies are often indirect and unintended. With respect to social and economic costs of forest destruction, it is fundamental for tropical forestry countries to establish policies that counteract the opportunities of deforestation in situations where forest clearing is inappropriate. These policies have as a goal to make forest conversion less profitable, or that other alternatives (either based on retaining forests or completely outside forest areas) be made more profitable. They can be grouped into six categories. Deforestation can be made less profitable by:

- Reducing the demand or prices for products produced from newly cleared land.
- Increasing the unit costs and riskiness of activities associated with deforestation.
- Eliminating speculative gains in land markets.

Alternatives to deforestation can be made more profitable by:

- Increasing the income stream to be obtained from maintaining forests.
- Reducing the costs of maintaining forests.
- Increasing the opportunity costs of labor and capital that might otherwise be used in activities associated with deforestation.

We shall examine three of these policies.

Reduction of prices and demand for tropical agricultural and forestry products

Demand for tropical products is a function of the size and incomes of the consuming population, relative prices, quantitative trade restrictions, and consumer preferences. Policies that affect any of these variables can also affect demand.

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High prices and demand for tropical agricultural commodities can stimulate the clearing of forests to produce these commodities. Therefore, policies that reduce the demand for tropical agricultural products can limit the conversion of forests to croplands and pastures. This approach has certain advantages. The policies involved are mostly national in scope, and governments can implement some of them easily and cheaply (at least with regard to their direct costs). However, these policies rely entirely on the market to distinguish where and how supply should be reduced, and this is unlikely to meet environmental objectives efficiently. In addition, it is difficult to win political support for policies that restrict the demand for or production of tropical products, particularly export products, and which restrict the incomes of primary producers in tropical developing countries.

Meanwhile, if high agricultural prices result from direct or indirect government subsidies, as is often the case, the argument for reducing demand by eliminating those subsidies is somewhat stronger. Market promotion and marketing boards have similar effects. They both reduce market risk and volatility and increase long-run average returns to producers. Under these circumstances, eliminating subsidies or marketing assistance for products from newly cleared forestlands may be effective, and low cost.

Per capita income greatly influences the demand for tropical products. However, the empirical evidence of this relationship is relatively weak and has been mostly based on the few 'tiger economies of East Asia', which may not reflect how the majority of tropical countries are likely to evolve in the future.

Exchange rate policies such as currency devaluations, designed to increase the relative price of tradable goods and services compared with non-tradables, generally increase real producer prices of tropical agricultural products, making it more profitable to convert forestland to agriculture (Wiebelt, 1994). However, because exchange rate policies are broad and far-reaching, under most circumstances concerns over inappropriate deforestation cannot be expected to be a major factor in their design.

Increase the costs and risks of production associated with deforestation

Substantial increase in taxes and charges set by governments for the exploitation of natural forests might reduce logging in inappropriate areas and marginalize some of the least efficient operators from the industry, who may also be amongst the most destructive.

Road construction also plays a crucial role in deforestation. The general idea is that new road construction presents the greatest threat to remaining forests by providing access to forested areas (Bryant *et al*., 1997). Roads are often essential both to market farm outputs and to deliver inputs to the farm and can greatly increase the profitability of agriculture and wood production in frontier areas. However, the road construction and transport policy reforms that might be required to reduce deforestation activities do not necessarily involve less road building, but rather a change in the nature, type, and location of roads built.

Increasing the opportunity costs of labor and capital

We are actually concerned here with the analysis of the possibilities of intervention that can increase the profit attached to maintenance and

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management of forests. Given that labor and capital are the principal factors of clearing forest and contribute less to their maintenance, increasing their opportunity costs can reduce the speed of deforestation. Policies that increase the opportunity costs of labor and capital include general policies that promote growth as well as specific policies that promote employment. To illustrate this, in Korea and Malaysia, where the opportunity costs of labor and capital are high, deforestation has considerably slowed and even been reversed. In other places where alternative returns to labor and capital remain low (Cambodia and Laos), deforestation rates remain high. This suggests possible connections between these costs and the extent of inappropriate deforestation (World Bank, 1994).

Employment growth in sectors like tourism, textiles, and manufacturing has increased labor opportunity costs to such an extent that it has reduced deforestation. Where deforesters have been left out of that growth, and no more attractive livelihoods have emerged, deforestation has continued. This implies that the sustainable promotion of non-rural employment reduces the type of forest conversion carried out by the poor with the aim of earning a living.

As a whole, it is important to mention that there is no perfect or general policy for the reduction of inappropriate deforestation. Each country has to choose from the set of factors examined above, a mix of variables, which can be specifically crafted to the local conditions of its environment.

Finally, it is worth mentioning the structural shifts that occurred in the Cameroon economy during the period under consideration. Between 1970 and 2000, three main structural shifts can be underlined in Cameroon, namely the oil boom, the Structural Adjustment Program (SAP) and the devaluation of the CFA franc.

During the oil boom, high international coffee and cocoa prices and more favorable producer price policies encouraged forest clearing to plant coffee and cocoa. Furthermore, government investment of oil revenues in parastatal oil palm (SOCAPALM) and rubber plantations (HEVECAM) fuelled deforestation. Wood harvest rose from 1.2 million cubic meters in 1977 to 2.1 million cubic meters in 1985 (Ndoye and Kaimowitz, 2000). Timber exports grew as well, but stagnated as companies sold more timber domestically (Foteu, 1995; World Bank, 1988). The oil boom stimulated construction, and this generated greater domestic demand for timber. However, food crop production apparently grew slowly during the oil boom due to promotion of rapid rural to urban migration (Ndoye and Kaimowitz, 2000).

Contrary to the oil boom, the Structural Adjustment policies induced a reduction of cocoa and coffee producer prices by 40 per cent and 60 per cent respectively in Cameroon (Blanford *et al*., 1994; Gbetnkom and Khan, 2002). Consequently, about 45 per cent of cocoa farmers in the East province abandoned their cocoa area in 1993 (Toornsta *et al*., 1994). With respect to the food crop sector, its growing importance severely affected deforestation compared with cocoa and coffee. As rural households found their incomes from cocoa and coffee collapsing, many compensated for those losses by increasing food production.

In January 1994, the CFA franc was finally devalued by 50 per cent. The new exchange rate greatly stimulated timber production, and this

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negatively affected large areas of forest. The devaluation doubled the prices timber companies received for their logs, but only increased their production costs by 34 per cent (Ndoye and Kaimowitz, 2000). This induced logging companies to increase their production. On average, log exports from Douala were almost twice as high in 1994–1996 as between 1987 and 1993. Concerning cocoa and coffee, producer prices for these two crops rose, and farmers responded to the increases by expanding their production. With respect to food crops, Sunderlin and Pokam (1998) reported that 48 per cent of plantain producers increased their cultivated areas between 1993 and 1997, as did 47 per cent of producers of other food crops. This is because urban dwellers consumed fewer imported foodstuffs, since the devaluation greatly raised their price. Meanwhile, the total number of urban consumers continued to grow.

In general, it is obvious from the reviewed studies that prices paid to the producers of coffee, cocoa, and food crops, the export price index of timber, the fertilizer price index, the monthly average revenue of farmers, the Gross National Product per capita, the credit to agriculture, and the changing economic conditions (oil boom, structural adjustment policies, and the devaluation of the CFA franc) are important immediate causes of deforestation in Cameroon.

3. Methodology

3.1. Model specification

From the theoretical framework presented in the previous section, we draw a linear model for empirical analysis of the form:

$$FOR = \alpha_0 + \alpha_1 coffeep + \alpha_2 cocoap + \alpha_3 timberp + \alpha_4 vaah + \alpha_5 GNPPC + \alpha_6 credit + \alpha_7 foodp + \alpha_8 fertp + \alpha_9 oilb + \alpha_{10} sap + \alpha_{11} dev + \mu_1 \quad (1)$$

α_i represents the respective coefficients of the independent variables, and μ is the error term associated to the regression of the equation. *FOR* stands for annual data on the forest area used to capture deforestation. The variables *coffeep*, *cocoap*, and *foodp*, are the prices paid to the producers of coffee, cocoa, and food crops respectively. *timberp* is the export price index of timber. The higher these prices, the more the forest area diminishes because of conversion of new forest portions and the export of timber. A negative relationship is therefore expected between these variables and *FOR* ($\alpha_1 \prec 0, \alpha_2 \prec 0, \alpha_3 \prec 0, \alpha_7 \prec 0$). *fertp* is the fertilizer price index. Assuming complementarity between fertilizer and land area, increased fertilizer prices will expand the area of cultivation. A negative relationship is expected ($\alpha_8 \prec 0$). *Vaah* is the agricultural value added per hectare. The higher this variable, the less the supplementary destruction of forest area. Thus, the expected relationship is positive ($\alpha_4 \succ 0$). *GNPPC* represents the Gross National Product per capita, which can be interpreted as a proxy for alternative employment opportunities. The higher it is, the less the dependency of the populations on the export of cash crops and forestry products. Thus, a positive relationship is expected ($\alpha_5 \succ 0$). *Credit* is the volume of credit destined for agriculture. It is one of the critical inputs necessary for small and large-scale production. The inadequacy

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of formal credit to farmers or the lack of it in farming operations may hinder farmers from undertaking investments in land improvements and better farm management practices to intensify production. An increase of this variable favors forest protection. The expected relationship is positive ($\alpha_6 \succ 0$). *Oilb*, *Sap*, and *Dev* are dummy variables designed to capture the effects of the oil boom, the structural adjustment policies, and the devaluation of the CFA franc on deforestation respectively. Each of these dummies takes 0 before the corresponding structural shift and 1 after. The expected relationship for the three is negative ($\alpha_9 \prec 0, \alpha_{10} \prec 0$, $\alpha_{11} \prec 0$).

The above linear empirical model is a variant of the model of Osei Asare and Obeng Asiedu (2000). However, it has originality for using two new variables, *Vaah* and *GNPPC*. The agricultural value added per hectare (*Vaah*) has a direct influence on deforestation. Its increase indicates an intensive agriculture; therefore the populations have no more interest in the extension of farmland and thus deforestation. This variable seems better attached to our preoccupation than the approximate monthly revenue of farmers used by the authors mentioned above, which is even very difficult to evaluate. The second variable is the GNP per capita, which influences deforestation as explained above.

3.2. Sources of data

As mentioned above, this paper aims at estimating the immediate causes of deforestation in Cameroon from 1970 to 2000. The data used in the analysis came from various sources. The main data source was the Department of Statistics and National Accounts. Information was obtained from the following documents: Cameroon in Figures, Annual Statistical Reports, and National Accounts documents. Other consulted sources include various reports from the World Bank, the Bank of Central African States and the FAO. All prices are deflated by the GDP deflator for 1993. Annual data on forest cover are collected from various FAO and World Bank Reports, and are measured in hectares (ha). Producer prices of cocoa and coffee, timber price index, and GNPPC expressed in CFA franc are from various issues of Cameroon in Figures, and Annual Statistical Reports. The average producer prices for food crops in CFA franc per kg are calculated from the prices of four main food crops in Cameroon (maize, millet, cassava, and plantains) that come from various issues of African Developments Indicators. The fertilizer prices in CFA franc per tone are obtained from some issues of 'Fertilizer's Statistic Yearbook' of the FAO. Credit to agriculture is used as a proxy for credit availability to farmers. It comes from various reports of the Bank of Central African States (BEAC). The agricultural value added per hectare is obtained from the World Bank's Economic and Social database (BESD).

3.3. Estimation technique

In this sub-section, we examine the time-series characteristics of the variables, testing for stationarity and cointegration of the variables in the equation under consideration.

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Unit root tests

We need to know the underlying process that generates our time-series variables. That is, whether the variables are stationary or non-stationary. Non-stationary variables might lead to spurious regressions. In this case, the results may suggest a statistically significant relationship between the variables in the model, when in fact this is just evidence of contemporaneous correlation. We have used the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) tests to examine our variables for the presence of a unit root. The ADF Test assumes that the data-generating process is autoregressive to the first order. This is done so that the autocorrelation in the error term does not bias the test. The ADF includes first-difference lags in such a way that the error term is distributed as a white noise. The test is formulated as follows:

$$\triangle y_t = \alpha + \rho y_{t-1} + \sum \gamma_j \triangle y_{t-1} + \varepsilon_t \tag{2}$$

A unit root test implies testing the significance of ρ against the null that $\rho = 0$.

The Phillips Perron (PP) Test for its part addresses the problem of the unknown structure of the data-generating process under the null hypothesis by adjusting the t-statistic for the potential omitted variable bias *ex post*. The PP test is formulated as follows:

$$\triangle y = \beta + \rho y_{t-1} + \mu_t \tag{3}$$

To test for a unit root, the above equation is estimated by OLS and the t-statistic of ρ is corrected for serial correlation. If the results of the unit root tests show that the variables are not stationary in their levels, we proceed with a cointegration analysis.

Cointegration analysis

In a regression involving non-stationary variables, spuriousness can only be avoided if a stationary cointegrating relationship is established between the variables. Therefore, if two or more variables can be linked together to form an equilibrium relationship spanning the long run, then even though the variables themselves may contain stochastic trends they will nevertheless move closer over time and the difference between them will be stable. To test for cointegration in this paper, we run our regressions and use the ADF and the PP unit root tests to test for the stationarity of the residuals. If the residuals are stationary, then we conclude for cointegration of series used in the model (Adam, 1993; Perman, 1989).

4. Empirical results

4.1. Unit root tests results

Table 1 in the appendix reports the results of the ADF and the PP tests for the order of integration of our variables. After comparing the ADF and PP statistics in table 1 with the Mackinnon critical values provided by the Eviews econometric package, we came up with the following conclusions concerning the unit root tests. Most of the variables are not stationary in their

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levels, implying the non-rejection of the null hypothesis of non-stationarity. But they all become stationary in their first differences. The examination of the correlograms leads to the same conclusions. This means that they all have a single unit root. Only one variable (credit) is stationary in its level. We cannot therefore specify our model in its level without the risk of obtaining spurious regressions except they are cointegrated. It is therefore necessary to carry out a cointegration test.

4.2. Cointegration test results

As described above, we ran our regressions and tested the residuals for the presence of unit roots. The results as presented in table 2 in the appendix reject the null hypothesis of no cointegration. The ADF and PP statistics presented in the table are significant at 1 per cent. In addition, the statistics of Durbin–Watson already indicate that the hypothesis of the absence of cointegration between the variables can be rejected (Pindyck and Rubinfeld, 1998).

4.3. Empirical results

We have used the ordinary least squares estimation procedure to obtain the results in table 2. These results meet our expectations in terms of their signs except *GNPPC* and credit, which present contrary signs. This is not the same situation with their levels of significance.

The estimated coefficients of the variables *coffeep*, *cocoap*, *foodp* and *timberp* are statistically significant at 10 per cent, 5 per cent, 1 per cent, and 5 per cent respectively with the expected negative signs. This indicates that the prices paid to farmers of coffee, cocoa, and food crop, and to exporters of timber effectively influence the speed of forest clearing in Cameroon. However, there is a difference in the response for annuals and perennials crops. The results show weak evidence of cocoa and coffee farmers responding in the short run[3] to price increases. This is because very often, farmers of perennials crops respond to price incentives in the short run by intensifying care and improving husbandry for their existing crops. Furthermore, since perennial export crops are less soil erosive, and productivity can be improved from rehabilitating existing plantations, it is obvious that forest clearing would be slower than for annual crops (Angelsen *et al*., 1999). Food crop farmers can easily respond to price incentives in the short run by expanding the land area. In addition, because most annual crops deplete soil fertility faster than cash crops, they require more new fertile land (Angelsen *et al*., 1999).

The fertilizer price index has the expected sign but is statistically insignificant. The behaviour of this variable can be explained either by the fact that farmers of perennial crops consume very negligible quantities of fertilizer or by the difficulties of obtaining reliable data on the variable. Angelsen *et al*. (1999) found this variable insignificant in Tanzania.

The agricultural value added per hectare (*Vaah*) is highly significant (1 per cent) with the expected positive sign. This variable measures what a farmer derives from his agricultural activities as profit per hectare. The

[3] The results with *cocoap* and *coffeep* lagged for three years, and *foodp* lagged for one year are not reported in the paper. These lagged variables were not significant and deteriorated the performance of the whole model.

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higher this profit, the less the attack by the farmer on parcels of forests. This variable can therefore be at the center of a governmental policy aimed at discouraging deforestation.

Credit to farmers does not have the expected sign, and is not significant. This can be linked to the fact that in Cameroon access to banking credits by small-scale farmers of rural zones who make up about 90 per cent of farmers is very difficult. Only a minority of farmers possessing modern agricultural tools can obtain credit. To reduce the weight of this problem, the government had established state structures to give small-scale subventions to peasant farmers (Fonader, Credit Agricole du Cameroun) unfortunately, both these structures disappeared during the economic reforms. The very negligible effect of bank loans on deforestation can also be the consequence of the absence of reliable data on this variable.

The three dummy variables *oilb, sap*, and *dev* designed to capture the three structural breaks that occurred in the Cameroon economy during the period under consideration in this paper have the expected signs, and are significant at 1 per cent, 5 per cent and 1 per cent respectively.

The GNPPC does not have the expected sign and is not significant. Its increase is assumed to reduce the demand of agricultural and forestry products.

As a whole, our model has performed well, because all the coefficients except two have the expected signs. However, in terms of their significance, some of our expectations were not met. The adjusted coefficient of determination (R^2) shows that the variables included in our model have succeeded to explain at 91 per cent deforestation in Cameroon. Osei Asare and Obeng Aseidu (2000) had 97 per cent in the case of Ghana. The Fisher Statistics (F-Stat) for the general performance of the model is significant. To test for serial correlation, we have used the Durbin–Watson statistic (DW). As appeared in table 2, the DW shows that the null hypothesis indicating the presence of a serial correlation has been rejected. All the probabilities of these two statistics are not significantly different from zero.

5. Conclusion

This paper aimed at addressing the immediate factors of deforestation in Cameroon and their magnitudes in the long run. The empirical evidence suggests that the producer prices of coffee, cocoa, timber prices, and food crop prices influence to various degrees the decision to cut down more wood for export and to convert forests into farmland. The agricultural value added per hectare positively affects forest cover. This means that its increase rather motivates the conservation of forests. The fertilizer price index, the credit to farmers and the per capita GNP have no effect on the activities of deforestation. Finally, the oil boom, the structural adjustment policies and the devaluation of the CFA franc have seriously increased the speed of deforestation in Cameroon.

The implications of these results are such that all attempts to slow down the speed of deforestation in Cameroon must take into account the influences of the significant variables in our model on this phenomenon. Meanwhile, the policies aimed at reducing the prices of agricultural products shall hardly get the support of the population, given that about 75 per cent of them depend on agriculture. In addition, it would be difficult to

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implement them in the actual context characterized by the liberalization of economies, which put an end to the stabilization of the cash crops prices. The agricultural value added per hectare, which measures what a farmer derives from his agricultural activities as profit per hectare increases the profitability of maintaining forests. This variable can therefore be at the center of governmental policies aimed at discouraging deforestation. This is possible through the promotion of an intensive farming system by increasing the amount of labor and capital applied per hectare of land. Whether the expansion of market demand and higher product prices lead to more or less pressure on the forest–agriculture frontier depends on the farmers' choice of technology (that is how much to intensify and how much to expand an area) in response to perceived opportunities.

Another implication of this study is that the new institutional tools for forest management and land-use planning in Cameroon (ONADEF, MINEF) have not yet provided a sustainable response to the problems of the progressive disappearance of forests.

Finally, a critical lesson from this paper is that policy measures outside of the formal forest sector are a key part of the problem of tropical deforestation in Cameroon, and, therefore, potentially a key part of the solution. This means that, prior to the crisis, and also during the crisis, governmental authorities did not pay sufficient attention to the unintended and the undesirable consequences of, inter alia, structural adjustment policies, urban and public sector employment policies, infrastructure policies, agricultural pricing and import policies, and exchange rate policies (Merten *et al*., 1999). In order to protect the remaining forest areas, attention to these policies should be a first-order priority in the future. It is obvious that governmental authorities will not alter exchange rates to protect forests, but environmental preoccupation should be taken into consideration when determining what macroeconomic policies to implement.

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Appendix

Table 1. *Unit root tests statistics*

	Levels		*First difference*	
	ADF	*PP*	*ADF*	*PP*
Log (timberp)	−2.01	−2.01	−4.65	−5.25
Log (cocoap)	−0.78	−0.69	−4.09	−4.51
Log (coffeep)	−1.85	−1.71	−3.63	−4.08
Log (credit)	−6.9	−4.25	–	–
Log (For)	−0.55	−0.73	−3.31	−4.85
Log (GNPPC)	−0.86	−0.86	−3.05	−3.05
Log (Vaah)	−1.97	−1.877	−3.17	−4.57
Log (Foodp)	−0.5	−0.172	−3.953	−4.04
Log (fertp)	−2.02	−1.674	−3.09	−3.855

Notes: The critical values of Mackinon for rejecting the hypothesis of the presence of a unit root at the 1 per cent, 5 per cent and 10 per cent levels are: ADF (−3.7497, −2.9969, −2.6381) and PP (−3.7343, −2.9907, −2.6348).

Table 2. *Results of the estimation of the function of determinants of deforestation*

Variables	*Coefficients*	*t-statistic*
Dependent variable log (FOR)		
Log (Coffeep)	−0.02816	−1.7601***
Log (Cocoap)	−0.0676	−2.1**
Log (timberp)	−0.0314	−2.15**
Log (Vaah)	0.03457	3.14*
Log (Credit)	−0.00422	−0.8411
Log (GNPPC)	−0.009611	−0.2334
Log (foodp)	−0.05816	−2.9402*
Log (fertp)	−0.0143	−0.996
Oilb	−0.0326	−3.204*
Sap	−0.0275	−2.456**
Dev	−0.0519	−3.35*
C	9.465	60.24*
ADF = −4.43	Durbin-Watson stat = 2.19	F-statistic = 162.35
PP = −6.493	S.D. dependent var = 0.00953	Prob (F-stat) = 0.0000
$R^2 = 0.9208$		S.E. of regression = 0.0253
$R^2 = 0.9127$		

Notes: *,**, and *** imply significance at 1 per cent, 5 per cent, and 10 per cent respectively.

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