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Wood Production in the Central African Republic's Economy: An Error Correction Model (ECM) Analysis

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Abstract *This work analyzes the effect of forest on the economy of Central African Republic, using the data from secondary source within the period of 1970-2015. The study employed error correction model (ECM) as econometric methodology to estimate the co-integration relationship among economic growth, agriculture value added, forest rent (in percentage of GDP) and forest product variables (logs, roundwood, wood fuel and sawnwood), it also estimates long run and short run relationship between variables. Augmented Dickey Fuller (ADF) unit root test were employed. The result shows that forests play an important role in the world's economy; they support both the economic growth and the ecosystem protection. The co-integration relationship result (using Engel-Granger) shows economic growth forest products variables (logs, roundwood, wood fuel and sawnwood) and other variables included in the model were co-integrated and therefore long run relationship exist among them. Testing the short run relationship shows the existence of short run relation between variables. The long run model shows logs production which the main exportable wood product in CAR having a positive and significant effect on the economy but we noticed that the affectation percentage is to low (0.08% change to GDP). This is due to the lack of control or traceability of the product and the luck of strong institutions (corruption) in the forestry sector.*

Key words Forest product, Economy of Central African Republic, natural resources

JEL Codes: O55

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1. Introduction

The Central African Republic is a landlocked country located in Central Africa in the north of the equator between 2° and 11° north latitude and between 14° 50' and 27°50' east longitude. It is limited by Sudan, South Sudan, Chad, Cameroon, the Republic of Congo and the Democratic Republic of the Congo. Its territory covers an area of 623 000 km^2, of which 65.23% are located on the north-western part of the Congo Basin (Boulvert, 1996).

Although the country has significant potential natural resources (dense hydrographic network, massive forestry, huge mineral resources), it records very alarming economic and social indicators. For instance, the level of education index is 0.43%, placing the country very far behind the other countries of Central Africa (Programas de las Naciones Unidas para el Desarrollo, 2015). The poverty index has increased, with a high polarization of the poor people in rural areas. The high concentration of the Central African population in rural areas (63%), the proportion of the active population in primary sector which share in GDP is around 53% is 74% and dependence of more than 80% of the population on wood energy, indicate how much Central African population make pressure on natural resources for their survival.

Mayaux (2004) have rather a different estimate of forests out of different sources of Central African Republic's forest cover, which results on the one hand, from a different method of identifying forests by satellite, and on the other hand, rely on another forest typology than that of FAO (Mayaux *et al.*, 2003). This estimate indicates forest cover in 2000 comprising 8227 million hectares of dense forest, 21,395 million hectares of forest mosaics and 24,746 million hectares of wooded bush zone. Of all kinds of typology, CAR has four major floristic domains: Sudano-Sahelian steppes, Sudan woodland, Sudano-Guinean woodlands, and dense equatorial forests (Gindre, 2008). The country contains some 3602 plant species, including 2.8% endemic.

Production forests cover a total area of nearly five million ha. They are operated by a limited number of enterprises on the basis of operating permits, which cover an average area of 300 000 ha. Wood production (logs and sawnwood) is estimated for 2007 at around 765 000 m3 (Gindre, 2008). Since 1996, the CAR has embarked on the reform of its forestry sector, notably the PARPAF project, through which development plans have been drawn up for almost 75% of operating permits. In addition, a new forestry code was adopted by the CAR National Assembly in September 2008. A significant portion of forest products (wood) in CAR is dedicated to export, but only a smaller amount is used for local consumption. With nearly 4,000 permanent employees and several thousand temporary workers, forestry remains the largest sector of formal private employment in CAR. In 2007, the forest sector accounted for 6.3% of GDP and its direct contribution to national tax revenues was about US $ 208 million, just over 10% of the total (World Bank, 2010) forests contribution to GDP

of all countries in the sub-region (Gindre, 2008). In 2011, we estimated the contribution of the forest sector to gross domestic product (GDP) at about 2.86% of the total of the six Congo Basin countries (Megevand, 2013). The contribution of the forest sector to the GDP and the economies of the countries in Congo Basin show a generally decreasing trend. However, the latter is not the same for all countries: while the curve is decreasing in Cameroon, Equatorial Guinea and the DRC, it is stable in the Congo and Gabon and is constantly growing in CAR (Tchatchou *et al*., 2015).

This paper is aimed to analyze through econometric tools the contributions of forest products exclusively dedicated to wood production, to the economy of Central African Republic (CAR).

2. Literature review

Many developing countries (Central African Republic) acquire foreign exchange through international trade of wood, thus fostering the expansion of the international trade of wood. In fact, the difference between countries' natural resource endowments and their unequal geographical distribution plays a crucial role in explaining international trade.

Traditional trade theory emphasizes that differences in factor endowments cause countries to specialize and export certain goods or services where they have a comparative advantage. This process allows for a more efficient allocation of resources, which in turn leads to an increase in trade gains which is the world's social welfare (WTO, 2010).

A country has a comparative advantage over others in producing a particular good when it can produce that good at a lower cost. This theory is one of the most fundamental ideas in economics and was introduced by David Ricardo (1772-1823) in his book Essay on Profit (Samuelson and Turner, 2015). However, Deardorff distinguishes two versions of the law of comparative advantage (Deardorff, 2014). Comparative advantage can be defined as the relatively low cost of a good compared to other self-sufficient countries (this double comparison between goods and countries is the critical element). It states that it is impossible by definition for a country to have a comparative disadvantage in each good. In practice, each country will have a comparative advantage in something. There are two laws of comparative advantage: the positive law that predicts what countries can do and the normative law that suggests what they should do. The positive version predicts that if a trade is allowed, a country will export goods in which it has a comparative advantage. The normative version suggests that if a trade is allowed, a country will benefit through specialization (WTO, 2008).

By focusing on resource endowments, Heckscher and Olin (Caliendo, 2011), extend the law of comparative advantage through their Heckscher-Ohlin theory of international trade. This states that a country will export the good that requires intensive use of the country's relatively abundant (and hence cheap) factor for its production, and will import the good that requires intensive use of the country's relatively rare (and therefore expensive) factor for its production. This includes cases where the natural resource is directly exported (after a minimal amount of processing) such as wood in the Central African Republic, rather than being used as an input into another product that is then sold in international markets. The Heckscher-Ohlin theory has been modified and expanded by introducing other factors than resource endowment, such as transportation costs, economies of scale, property rights, and government policies that also influence the comparative advantage. Forests products especially timber have been subject to many research in economic literature.

Kalu and Okojie (2009) showed through their study of the economic contribution of the forest to Nigeria's GDP during the period 1970-2000 that forestry had an impact on gross domestic product (GDP) in Nigeria revealed by the study carried out. collecting data from the Forestry Directory, the Federal Statistical Office and the annual reports of the Central Bank of Nigeria (CBN) for the thirty-year period (1970-2000) (Bojang and Ndeso-Atanga, 2011). Using Ordinary Least Squared (OLS) to analyze their data, the results showed that export of timber and price index of timber increased GDP in 0.23 and 13.2% respectively (Sciences and Publication, 2009). Njoroge and Muli (2011) have examined the forest significance as source of energy, source of income and ecological protection regarding Rwanda, one of African economies with a remarkable economic growth nowadays. Wood is the principal source of energy in Rwanda where forest accounts for proximately 84% of current primary energy use. 96.2% of all households use wood as a source of energy. Rudzani and Saidi (2011) also related the socio-economic and environmental significance of plantation forest in South-Africa. First of all, they attested that plantation forest contribute to the livelihood of the society where they found. In fact, in South-Africa, most of the plantation forests are in the rural area where more than 75% of rural communities people that live are poor. Economically, the direct benefits of these forests are the creation of sustaining jobs and their contributions to GDP (Bojang and Ndeso-Atanga, 2011). Researchers have shown that the creation of employment and business opportunities within the forestry sector is probably the most significant contribution that forestry could make towards provision of household food security and improvement of rural people's livelihoods (FAO, 2016; Ofoegbu, 2010). The level of employment in e forestry sector is thus an indicator of both the social and economic value of the sector to the society (FAO, 2015).

Forests provide a wide variety of tangible and intangible benefits to the population as a whole and are a primary source of livelihood for millions of poor people. However, the forestry sector's contribution to India's GDP in 2007-2008 was only 0.7%, which is very small compared to its actual contribution. The main reasons for the low contribution of the forestry sector are a strong underestimate; undervaluation and lack of registration of most forest benefits in the conventional forest resource accounting (FRA) system (CDR, 2013).

The forest sector contributes a significant share to national income even in rich countries according the Jaunky and Landmark's work (Surgxfwv *et al*., 2016). Their study attempts to test the growth assumption of forest product exports for 22 economies over the period 1970-2011 and uses an error correction model (ECM) to analyze the link between economic growth and the export of forest products. It should be recalled that the ECM is then used to estimate short- and long-run elasticity and the results revealed that the export of forest products positively affects economic growth. Short-term elasticity reveals positive and significant income elasticity. Their study also showed that a 1% increase in forest product exports would result in economic growth of 0.022% in the short term and 0.002% in the long term. The regional dummy variable is also significant and positive; indicating that countries with significant forest land cover will inevitably experience higher economic growth. In general, the results support the ELG hypothesis. The promotion of forest products exports can have a multiplier effect. While forest resources can make a significant contribution to the economy, on the other hand, the economy can also affect forests. Se-Bin Kim and Dong-Jun Kim also examined econometrically the impacts of economic growth on the consumption of forest products in Korea for the period 1980-2013 (Kim, 2015)[1].

3. Methodology of research

Since the wood production is mostly located in the closed forest of the south-west part of Central African Republic which forms the northern farthest point of the Congo Basin forest (Atlas 2010) this work will focus on this part in order to bring out the analysis we would like to make. We will synthesize existing information on the forest exploitation in Central African Republic, based mainly on the bibliographic review for getting data. These data are time-series data of secondary source from in the range of 1970-ntral Africa2015. Since the data we are using are annual data (low frequency), we use Error Correction Model (ECM) to test the short and the long term relationship between wood products and the economy of Central African Republic through its Gross Domestic Product. Doing so, Engel-Granger cointegration also will be used to test if variables are cointegrated. Therefore we can establish the multiple regressions (static model) we are using as follow:

$$LGDPMP_t = \beta_0 + \beta_1 LAVA_t + \beta_2 FRGDP_t + \beta_3 MRGDP_t + \beta_4 LRWood_t + \beta_5 LSVlog_t + \beta_6 LWoodF_t + \mu_t \quad (1)$$

Where:

Gross Domestic Product in Market Price (GDPMP) is the real GDP at constant market price of 2010.

Agricultural Value Added (AVA) is the sum of all the values added from different agricultural sector.

Forest rents as a percentage of GDP (FRGDP) are defined as roundwood harvests multiplied by the product of average prices and by a region-specific rental rate. This index is calculated for each country according to the method established by the World Bank in its report entitled "*The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium*" (World Bank, 2011). Mineral rents as a percentage of GDP (MRGDP) are also, by definition, the difference between the value of production of a mineral stock at world prices and their total production costs. The minerals included in the calculation are tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite and phosphate. Roundwood (RWOOD) is roundwood that is cut or otherwise harvested and removed. Sawn log and Veneer Logs (SVLOGS) are roundwood that are sawn (or chipped) longitudinally for the manufacture of sawnwood or railway sleepers or used for the production of veneers (mainly by peeling or slicing). Timber (SWOOD), wood that has been produced from domestic and imported roundwood, either by longitudinal sawing or peeling and which, with some exceptions, exceeds 5 mm in thickness. And Woodfuel (WOODF) is a round wood that will be used as fuel for cooking, heating or energy production.

[1] We consider South Korea as developed country because although a few index providers may disagree, but South Korea is widely regarded as having joined the developed world. *https://www.investopedia.com/updates/top-developing-countries*

4. Data analysis

Table 1. Stationary test result (ADF)

	Level			First difference		
Variables	ADF CandT	Critical Value (5%)	Result	ADF CandT	Critical Value (5%)	Result
AVA	-1.322698 (0.6110)	-2.928142	I(1)	-5.856996 (0.0000)	-2.929734	I(0)
FRGDP	-1.835624 (0.3590)	-2.928142	I(1)	-8.246402 (0.0000)	-2.929734	I(0)
GDPMP	-2.040810 (0.2690)	-2.928142	I(1)	-6.713742 (0.0000)	-2.929734	I(0)
MRGDP	-2.542479 (0.1127)	-2.928142	I(1)	-6.525347 (0.0000)	-2.929734	I(0)
RWOOD	-1471518 (0.5381)	-2.928142	I(1)	-8.089934 (0.6098)	-2.929734	I(0)
SVLOGS	-1.894588 (0.3319)	-2.928142	I(1)	-7.475021 (0.0000)	-2.929734	I(0)
SWOOD	-2.291226 (0.1791)	-2.928142	I(1)	-6.919294 (0.0000)	-2.929734	I(0)
WOODF	-1.096018 (0.7094)	-2.928142	I(1)	-6150354 (0.0000)	-2.929734	I(0)

Figures in bracket denote MacKinnon (1996) one-sided p-values.

All the variables are stationary at first difference.

Table 2. Long run model result

Dependent variable: LGDPMP

Variables	Coefficients	t-values	Probability
C	23.06373	15.42374	0.0000
LAVA	0.221139	11.39284	0.0000
FRGDP	-0.024055	-5.402595	0.0000
LRWOOD	-1.890208	-3.224809	0.0025
LSVLOGS	0.287054	3.722225	0.0006
LWOODF	1.256457	2.623174	0.0123
R^2= 0.884318 Adj. R^2= 0.869858 F-statistic= 61.15499 p-value= 0.00000			

***Source*:** Author computation

With LGDPMP the natural logarithm value of the real GDP at constant market price of 2010, LAVA the natural logarithm value of the sum of all the values added from agricultural sector, LFRGDP the natural logarithm value of forest rents in percentage of GDP, LRWOOD, LSVLOGS, LSWOOD are natural logarithm values of RWOOD (round wood), SVLOGS (sawn and veneer logs), SWOOD (sawn wood) and WOODF (wood fuel) respectively.

After estimating the long run equation, we should apply the EG cointegration in order to see if the variables are cointegrate.

Table 3. Engel-Granger cointegration

Null Hypothesis: ECT has a unit root

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.529200	0.0007
Test critical values:	-3.584743	
	-2.928142	
	-2.602225	

*MacKinnon (1996) one-sided p-values.

The result (table 3) shows that all the variables are cointegrated in Engel-Granger because the Error Correction Term (ECT) which is the residual of long run equation does not have unit root, therefore it is stationary (white noise). Since variables are cointegrated we can implement the short run model (Error Correction Model) in order to analyze the short run relationship between dependent and independent variables.

Table 4. Short run (ECM) estimation output

Dependent variable: D(LGDPMP)

Variables	Coefficients	t-values	Probability
C	-0.015036	-2.076526	0.0447
D(LAVA)	0.385211	8.186116	0.0000
D(FRGDP)	-0.010001	-2.580758	0.0138
D(LRWOOD)	-1.396746	-2.826118	0.0075
D(LSVLOGS)	0.177481	3.069731	0.0039
D(LWOODF)	0.817437	2.097134	0.0427
ECT(-1)	-0.463019	-3.604993	0.0009
R^2= 0.755593 Adj. R^2= 0.717002 F-statistic= 19.57972 p-value= 0.00000			

D denotes the first difference of the variables, L, the natural logarithm value, GDPMP the real GDP at constant market price of 2010, AVA the sum of all the values added from agricultural sector, FRGDP forest rents in percentage of GDP, RWOOD round wood, SVLOGS sawn and veneer logs, SWOOD sawn wood and WOODF wood fuel.

5. Results

According to our data analysis the result of the unit root test show that all variables were not stationary at level as we can see; the value of ADF test statistics is less than critical value at 5 percent level for all variables. These can also be discern from probability values greater than 0.05, it's mean that we cannot reject null hypothesis of unit root in these variables therefore they have unit-root or they are not stationary and should carry out the test again at first difference. The ADF (table 1) values at first difference are greater than critical value at 5 percent, the probability in parentheses shows values less than 0.05, hence we reject null hypothesis of unit root (no unit root) for all variables at first difference, all other variables are integrated of order one I(1). This allows us to perform our multiple-regression without any risk of spurious model.

In the long run the result of the shows that agriculture has a positive impact on CAR GDP through its value added and is statistically significant at the 5% level with a statistical value of 11.39284 greater than 2. This is a one percent change of agricultural value added lead GDP to increase by 22 percent. This figure is less consistent, since in reality the agricultural sector plays an important role in the Central African economy because it contributes more than 50% of GDP.

We can help agricultural development because the country has essentially large land suitable and available for agriculture and also open water resources that give it an advantage over other regions. This future agricultural development could, however, be undertaken at the expense of forests.

We can also see through this result that the forest rent is statistically significant with a t- value of -5.402595 greater than 2 and has a long run negative effect on GDP. In fact a one percent of change in forest rent decreases GDP by (-0.024055) which is not consistent with our priori expectation. By definition forest rent is a round wood harvest time the product of average prices and a region-specific rental rate. CAR's balance of trade is frequently deficit compared to other countries in Central African region, so this can affect its economy negatively regarding regional or international indexes. Thus in order to get the true effect of the forest rent on the GDP we take the amplitude value (absolute value) of the coefficient. Therefore we can consider that the one unit change in forest rent value will lead to 0.02% change in GDP in amplitude. Roundwood is statistically significant with a t-statistic value of -3.224809 but has also a long run negative effect on the GDP (-1.890208), change in roundwood of 1% will cause GDP to change by -1.9% (1.9% in amplitude).

Logs production which the main exportable wood production in CAR is statistically significant (3.722225) and has a positive long run affectability on the GDP (0.077119) according to the result of our analysis. Consistent with previous analysis, the one percent change in the production of logs will lead the GDP to change by about 0.08%. Finally, the result shows that wood fuel also is statistically significant with t-value worth of 2.623174 > 2 and change in the same direction with GDP in the long run. Thus a change of one percent in wood fuel production will make a change in GDP of 1.25%. This high percentage of the effect of wood fuel on GDP is valuable because wood fuel is the main energy source for households. We shall recall that wood fuel is produced locally by the population either as firewood or charcoal.

The adj. R^2 0.869 shows 87 percent of variation in dependent variable is explained by independent variables. The joint significant given by F-stat 61.15 p-value (0.00) shows that independent variables are significant determinant of dependent variable.

According to Engel-Granger co-integration theorem for any co-integrating variables there must be error correction term in short run. Table 12 informs us about the error correction term coefficient and short run coefficients estimate. The error correction term (ECT) is negative and significant at 5 percent. The ECM(-1) coefficient is 0.46 an indication of slowing pace of adjustment to equilibrium path, it implies that for any disequilibrium from long run path in short run 46 percent of disequilibrium from the long run path are corrected each year.

Therefore, in the short run first difference of the logarithm value of agriculture's value added is statistically significant at 5 percent. That is mean agricultural through its value added has an immediate (short run) effect on the GDP. Once again this is relevant with the reality because the economy of Central African Republic is heavily based on agriculture. Forest rent and roundwood have a negative impact on GDP in short run; sawn and veneer logs have an immediate positive impact on GDP and finally, woodfuel also has a positive effect on GDP in short run.

The adj. R^2 0.717 shows 72 percent of variation in dependent variable is explained by independent variables. The joint significant given by F-stat 19.57 p-value (0.00) shows that independent variables are significant determinant of dependent variable. The DW 1.98 and the serial correlation test (table) show that model does not from serial correlation. Table shows also that the model suffer from misspecification.

6. Conclusions

Forests play an important role in the world's economy; they support both the economic growth and the ecosystem protection. In Central African Republic forests represent an important resource for the economy and an exceptional economic resource for the country. The forestry sector (enterprises) in considered as the first formal private sector that contribute to the reduction of unemployment in the country. It absorbs nearly 4,000 permanent employees and several thousand temporary workers. After independence, since the CAR's government take over the control of its forest resources, some efforts have been made that attempt to bring the forest management towards a rational use of the resources.

This work analyzes the effect of forest on the economy of Central African Republic, using the data from secondary source within the period of 1970-2015. The study employed error correction model (ECM) as econometric methodology to estimate the co-integration relationship among economic growth, agriculture value added, forest rent (in percentage of GDP) and forest product variables (logs, roundwood, wood fuel and sawnwood), it also estimates long run and short run relationship between variables. Augmented Dickey Fuller (ADF) unit root test were employed.

ADF test shows all variables were not stationary at level, they are integrated of order one I(1) rural population which was not integrated at level neither at order one and was remove from the model; Philip-Parron test has similar result with ADF test. The co-integration relationship result (using Engel-Granger) shows economic growth, agriculture value added, forest rent and forest product variables (logs, roundwood, wood fuel and sawnwood) were co-integrated and therefore long run relationship exist among them. Testing the short run relationship shows the existence of short run relation between variables.

In the long run analysis, the Granger-Engel co-integration test shows that all the independent variables have the long run relationship with the dependent variable. In fact, in a long run model there likely exist an error correction term which is the residual of the model. And after testing the stationarity of this error correction term we confirm the relevance of the long run relationship since the ECT does not have unit root. The long run model shows that agriculture sector which is an important sector to the CAR's has a positive and significant effect on the GDP growth. Agriculture was included to the model because it is the main threat factor to the forest. Logs production which the main exportable wood product in CAR also has a positive and significant effect on the economy but we noticed that the affectation percentage is to low (0.08% change to GDP). This is due to the lack of control or traceability of the product and the luck of strong institutions (corruption) in the forestry sector. Finally woodfuel which is the main energy source for household in CAR has also a positive and significant effect on the economy with a high percentage (1.25%).

In the sort run all the independent variables (agriculture value added, forest rent, roundwood, sawn and veneer logs and wood fuel) have a short run relationship with the dependent variable (GDP) and behave in the same way as in the long run. The model also shows that error correction term (ECT(-1)) has the expected sign and significance and therefore, attests that for any disequilibrium from long run path in short run 46 percent of disequilibrium from the long run path is corrected each year due to the existence of the error correction term and its statistical significance.

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