The analysis of the total factors productivity growth in waemu banks:the x efficiency approach

Zoma, Isae Armand

Ecole Nationale de Statistiques et d' Economie Appliquée (ENSEA-Abidjan)

June 2010

The analysis of the total factors productivity growth in WAEMU banks: the X efficiency approach

Abstract.

In this paper, we make an analysis of productivity's gaps in WAEMU's banks; the intra-organizational strategy is privileged. For that purpose, we study the progression of the global factors productivity using the Data Envelopment Analysis (DEA), and then the X efficiency scores are calculated using stochastical frontier approach (SFA). The study period (2002 to 2006) corresponds to the post financial liberalization in the zone and to a changed banking and financial environment. We find that the global productivity of the factors remained relatively unchanged but that globally the X efficiency of the banks lightly decreased, remaining nevertheless at a relatively high level of the order of 80% .Big banks, of the viewpoint of their size and the private and semi-public banks, of the viewpoint of their capital structure, have the biggest mean scores of X efficiency.

Keywords: bank, WAEMU, productivity, global productivity, X efficiency, DEA, SFA.
JEL Classification D24 G21

1. Introduction

With the changes in the regulation of its financial market, the WAEMU zone attempts to facilitate the process of financial integration and convergence in West Africa. For the banks, the resulting competition and the possibility to operate on a large market pose with acuteness the problem of the banking production costs mastery. They have to improve their productive efficiency. The productive efficiency of a complex productive system is the aptitude gotten in the capacity to mobilize human and non-human resources to produce goods and services in shapes and costs required by the demand. Both technical parts and organization are concerned. In the literature relative to banks performance there are essentially two main families of methods: the parametric method and the non-parametric one. The latter, notably the DEA method has a major inconvenience; it doesn't take into account data errors. As for the parametric method, it is necessary to be able to give a shape functional to the efficiency border. Both methods will be used. The technical aspects of the performance will especially be approached from the DEA (used for the calculation of Malmquist indexes) combined to the bootstrap methods. Banks have an objective of minimization of their costs in relation to the profits that they make. They organize themselves consequently.This aspect of their performance will be appreciated from the parametric stochastic border method and by the use of a cost translogarithmic function .This will permit us to calculate the banks X efficiency scores. Our approach will also permit us to compare X efficiency calculated following the two optics.

2. Methodology

2.1. Malmquist productivity indexes

The indexes of Malmquist are a measure of the productivity change which taking into account the technological and the technical efficiency changes. Furthermore the use of the indices of Malmquist doesn't require any knowledge of the inputs prices nor the outputs prices. The technical efficiency change can be divided in pure technical change and change of scale efficiency. The technical efficiency measures the faculty of a production unit to get the possible outputs maximum from a given combination of inputs and technology of production (definition " oriented output "), or its faculty to produce a given level of output from the smallest possible input quantities (definition " oriented input "). The technical inefficiency corresponds therefore either to a production lower than what is technically possible for a given quantity of inputs and a technology, or to the use of quantities of inputs over of the necessary for a level of output given. The efficiency of scale follows refers to the evolution of the production when of the quantity used of factors increases. The pure technical efficiency reflects the resource management, the incentive, the surveillance and the organization in the work unit, notions that are linked to X efficiency.

Let us consider an output oriented productivity indices. We suppose that at each period $t = 1,2, \dots T$ the production technology S^t , represents inputs $x^t \in \Re_+^n$ transformation in to outputs $y^t \in \Re_+^m$. S^t={ (x^t, y^t) x^tcan produce y^t} . The output distance function at time ț as defined by Shepard (1970) is $D_0^t(x^t, y^t) = \inf\left\{\alpha \middle| \left(x^t, \frac{y^t}{\alpha}\right) \in S^t\right\} = (\sup\{\alpha|(x^t, \alpha y^t) \in$ $St{-}1$.

This distance function measures the maximal proportional change in output required to make (x^t, y^t) feasible in relation to technology at time t. To define Malmquist indices, we need the output distance function related to two periods :

$M_C(x^{t_1}, y^{t_1}, x^{t_2}, y^{t_2}) = \left[\frac{D_0^{t_1}(x^{t_2},y^{t_2})}{D_0^{t_1}(x^{t_1},y^{t_1})} \times \frac{D_0^{t_2}(x^{t_2},y^{t_2})}{D_0^{t_2}(x^{t_1},y^{t_1})}\right]^{\frac{1}{2}}$; thus the technical efficiency change component and the technical change component will be as follows :

$$\mathrm{M_C}(\mathrm{x}^{t_1},\mathrm{y}^{t_1},\mathrm{x}^{t_2},\mathrm{y}^{t_2}) = \underbrace{\frac{\mathrm{D}_0^{t2}(\mathrm{x}^{t2},\mathrm{y}^{t2})}{\mathrm{D}_0^{t1}(\mathrm{x}^{t1},\mathrm{y}^{t1})}}_{\text{technical efficiency change}} \underbrace{\left[\frac{\mathrm{D}_0^{t1}(\mathrm{x}^{t2},\mathrm{y}^{t2})}{\mathrm{D}_0^{t2}(\mathrm{x}^{t2},\mathrm{y}^{t2})} \times \frac{\mathrm{D}_0^{t1}(\mathrm{x}^{t1},\mathrm{y}^{t1})}{\mathrm{D}_0^{t2}(\mathrm{x}^{t1},\mathrm{y}^{t1})}\right]^{\frac{1}{2}}}_{\text{Technical change}}.$$

Maintaining the hypothesis of variable returns to scale technology, the technical efficiency change index may be further decomposed into two components, the pure technical efficiency change[1] and the scale efficiency change.

$$\mathrm{M_C}(\mathrm{x}^{t_1},\mathrm{y}^{t_1},\mathrm{x}^{t_2},\mathrm{y}^{t_2}) = \underbrace{\frac{\mathrm{D}_{0V}^{t_2}(\mathrm{x}^{t_2},\mathrm{y}^{t_2})}{\mathrm{D}_{0V}^{t_1}(\mathrm{x}^{t_1},\mathrm{y}^{t_1})}}_{\text{pure technical efficiency change}} \underbrace{\frac{\mathrm{D}_0^{t_2}(\mathrm{x}^{t_2},\mathrm{y}^{t_2})}{\mathrm{D}_0^{t_1}(\mathrm{x}^{t_1},\mathrm{y}^{t_1})} \Big/ \frac{\mathrm{D}_{0V}^{t_2}(\mathrm{x}^{t_2},\mathrm{y}^{t_2})}{\mathrm{D}_{0V}^{t_1}(\mathrm{x}^{t_1},\mathrm{y}^{t_1})}}_{\text{scale efficiency change}} \underbrace{\left[\frac{\mathrm{D}_0^{t_1}(\mathrm{x}^{t_2},\mathrm{y}^{t_2})}{\mathrm{D}_0^{t_2}(\mathrm{x}^{t_2},\mathrm{y}^{t_2})} \times \frac{\mathrm{D}_0^{t_1}(\mathrm{x}^{t_1},\mathrm{y}^{t_1})}{\mathrm{D}_0^{t_2}(\mathrm{x}^{t_1},\mathrm{y}^{t_1})}\right]^{\frac{1}{2}}}_{\text{Technical change}}$$

Practically, we consider that banks use human capital (number of employees), physical capital (immobilisations) and financial capital (financial charges) to produce two outputs : loans and investment's titles.

2.2. Stochastical Frontier Approach

It's has been developed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). But, changes has been introduced in the original model including the use of panels data and cost functions.

Battese et Coelli specification (1995)

$y_{it} = X_{it}\beta + (v_{it} - u_{it})$ Where

y_{it} is the firm i production or production logarithm at the time t

X_{it} is the firm i inputs vector at the time t

β is a parameter to estimate

v_{it} are random variables which are assumed to be iid[2] $N(0, \sigma_V^2)$ and independent of the

u_{it} which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(m_{it}, \sigma_U^2)$ distribution , where

$m_{it} = z_{it}\delta$, z_{it} is a p*1 vector of variables which may influence the efficiency of a firm, and , a 1*p vector of parameters to be estimated

Schmidt et Lovell specification (1979)

$C_{it} = X_{it}\beta + (v_{it} + u_{it})$ Where

C_{it} is the firm i cost or cost logarithm at the time t and X_{it} , β, v_{it}, u_{it} are as defined earlier.

[1] The « V » indicates that the output distance function is computed under the assumption of variable returns to scale technology

[2] Independant and Identically distributed

With $\sigma^2 = \sigma_U^2 + \sigma_V^2$ and $\gamma = \frac{\sigma_U^2}{\sigma_U^2+\sigma_V^2}$ the measure of cost inefficiencies relative to the cost frontier is as

$$E(U|\varepsilon) = [\sigma^2\gamma/(1+\gamma^2)]\left[\frac{\phi\left(\frac{\mu^*}{\sigma^2}\right)}{\Phi\left(\frac{\mu^*}{\sigma^2}\right)} + \frac{\mu^*}{\sigma^2}\right] \quad \text{[Battese and Coelli (1993)]}$$

where $\mu^* = \varepsilon\,\gamma$, $\varepsilon_{it} = v_{it} + u_{it}$, ϕ is the standard normal density function, and Φ the cumulative normal density function.

The cost function we use for this study is a translogaritmic one. Its take into account the multi - products character of the banks and the complexity of their production's technologies (variabe scale return and elasticiy of substitution) .

$$\ln(CT)_{\mathrm{it}} = \alpha_0 + \sum_{j=1}^{n} \alpha_j \ln(y_j) + \sum_{l=1}^{m} \beta_l \ln(p_l) + \frac{1}{2}\sum_{j=1}^{n}\sum_{l=1}^{n} \alpha_{\mathrm{jl}} \ln(y_j)\ln(y_l) + \frac{1}{2}\sum_{J=1}^{m}\sum_{L=1}^{m} \beta_{JL} \ln(p_J)\, ln(p_L) + \sum_{j=1}^{n}\sum_{l=1}^{m} \phi_{\mathrm{jl}} \ln(y_j)\ln(p_l) + u_{it} + v_{it}$$

$\mathrm{y} = (\mathrm{y}_1, \dots, \mathrm{y}_\mathrm{n})$ outputs vector in monetary units.

$\mathrm{p} = (\mathrm{p}_1,\dots,\mathrm{p}_\mathrm{m})$ inputs prices vector.

Practically, banking costs are financial and operating. Financial costs include charges in interest particularly on the deposits and on the banks debts in general. Operating costs are about salaries, taxes, physical capital pay-off, exploitation charges.

3. Empirical findings

3.1 Non- parametric method

The following table shows the WAEMU's banks global factors productivity growth and its components between 2002 and 2006. We note an improvement for Senegal (2.9%), Burkina Faso (2.3%), Niger (1.4%), Benin (0.27%) and a deterioration for Ivory Coast (-1.7%), Guinee Bissau (-1.5%), Mali (-3%), Togo (-0.17%).

Table 1: WAEMU's banks global factors productivity growth and its components between 2002 and 2006

	Country	Technical efficiency	Technological change	Pure technical efficiency	Scale efficiency change	Total factors productivity
1	Benin	0.997	1.008	1.011	0.985	1.0027
2	Burkina Faso	0.969	1.061	1.034	0.936	1.0234
3	Ivory Coast	0.985	0.998	1.004	0.982	0.9828
4	Guinee Bissau	0.976	1.009	0.858	1.138	0.9851
5	Mali	0.959	1.014	0.978	0.980	0.9695
6	Niger	0.921	1.103	0.976	0.945	1.0142
7	Senegal	1.014	1.017	1.026	0.989	1.0293
8	Togo	0.937	1.068	0.999	0.937	0.9983
9	WAEMU	0.970	1.035	0.986	0.986	1.0007

Technological change is important (+3.5%). Togo's banks productivity, very slightly declined (-0.02%) even if their technological change evolved in a positive way (+6.8%). So are Guinee Bissau and Mali's banks. All countries except Guinee Bissau registered a decreasing of their scale efficiency and in all countries except Senegal there is a decreasing of global technical efficiency. Scale inefficiencies dominate technical inefficiencies except for Guinee Bissau and for Mali. As a rule WAEMU's banks operate in an inappropriate scale level. This situation is combined to a sub using of inputs as the 1.4% decrease of pure technical efficiency suggests.

Table 2: WAEMU's banks global factors productivity growth and its components between 2002 and 2006, according to the size

	Banks Category	Technical efficiency	Technological change	Pure technical efficiency	Scale efficiency change	Total factors productivity
1	Small	0.963	1.047	0.992	0.971	1.006
2	Average	0.979	0.997	1.020	0.959	0.980
3	Big	0.994	1.029	1.005	0.988	1.021

The global technical efficiency of the banks increases with their size. We also find that this size factor is an determining element in the efficiency of resources use. Indeed while the small banks know a decrease of their pure technical efficiency (-0.08%), the average and the big banks improve their score respectively of 2% and 0.5% .

Table 3: WAEMU's banks global factors productivity growth and its components between 2002 and 2006, according to their capital structure

	Banks category	Technical efficiency	Technological change	Pure technical efficiency	Scale efficiency change	Total factors productivity
1	Private	0.993	1.016	1.007	0.987	1.008
2	Semi Private[3]	0.961	1.042	0.999	0.962	0.998
3	Semi Public	0.912	1.041	0.969	0.939	0.945
4	Public	1.015	1.018	1.035	0.981	1.034

[3] We call Semi Private bank, a bank for which more than a half of its capital is owned by private investors and Semi Public bank, a bank for which less than a half of its capital is owned by private investors.

Our sample only includes two public banks and two semi public banks. Within the public banks, the global productivity of the factors, the global technical efficiency and the pure technical efficiency noticed better evolutions paradoxically in comparison to the other categories of banks.

3.2 Parametric method

Table 4 : X efficiency scores by countries

Country	Mean	minimum	maximum	Standard Error	CV[4]
Benin	0.8085	0.6481	0.8718	0.0853	0.1056
Burkina Faso	0.8559	0.6643	0.9539	0.1031	0.1204
Ivory Coast	0.8740	0.7310	0.9637	0.0661	0.0757
Guinee Bissau	0.7949	0.7659	0.8362	0.0255	0.0321
Mali	0.7769	0.5904	0.9441	0.1252	0.1611
Niger	0.7560	0.5535	0.9071	0.1311	0.1734
Senegal	0.8647	0.6983	0.9522	0.0798	0.0922
Togo	0.6581	0.5148	0.9656	0.1650	0.2507
WAEMU	0.8143	0.5148	0.9656	0.1192	0.1463

When we consider WAEMU space, we notice an enough elevated level of the efficiency scores (81.4%). While examining the situation of the countries in an isolated way, the results are as follows. The best scores are obtained by Ivory Coast (87.4%) and Senegal (86.4%). The least satisfactory are those of Niger (75.6%) and Togo (65.8%).The results especially gotten for Ivory Coast can seem surprising, as far as the study period corresponds to the politico -military crisis the country has suffered from. As the size analyzes will show, big banks get high scores of efficiency. But, ten (10) of the fourteen (14) banks of Ivory Coast are either average or big banks. This can explain a little bit this result.

Except for Benin (2%), Burkina (0.7%) and the Guinea Bissau (0.05%), efficiency scores noticed a decreasing trend: -2. 2% for Ivory Coast, -4% for Mali, -0. 9% for Niger, -0. 7% for Senegal, -2. 7% Togo. The WAEMU registered an average rate of growth of the scores of -1. 3%. The situation of Togo is particular. It is the country where we observe the two extremes of scores but it has the strongest rate of bancarisation of the WAEMU zone (21. 6% in 2007).

[4] Coefficient of variation

Tableau 5 : X efficiency scores by size

Banks category	Mean	Minimum	Maximum	Standard Error	CV
Small	0.7901	0.5148	0.9656	0.1251	0.1583
Average	0.8052	0.5806	0.9539	0.1347	0.1672
Big	0.8718	0.7309	0.9522	0.0663	0.0760

As those results suggest, it appears that efficiency is positively linked to the banks size define here by the total of assets. Nevertheless it is necessary to qualify these results: the best mean score is gotten by the smallest bank in our sample.

Tableau 10 : X efficiency scores by capital structure

Banks category	Mean	Minimum	Maximum	Standard Error	CV
Private	0.8242	0.8009	0.8443	0.0161	0.0196
Semi Private	0.8285	0.8095	0.8608	0.0217	0.0262
Semi Public	0.6306	0.5021	0.7528	0.1030	0.1633
Public	0.6609	0.5261	0.7852	0.1215	0.1838

The most efficient banks are the private (0. 8242) and the semi-private (0. 8285) banks. The strong coefficients of variation for the last two groups (Semi- public and public banks) don't mean that the increase of the state involvement in the capital structure is a dispersing factor of efficiency. For the public banks, they rather come from the fact that this group has 2 entities whose results are different: 0. 80 for the NBI (National Bank of Investment, Ivory Coast) and 0. 51 for the TUB (Togolese Union of Bank); for the semi-public banks [IBM (International Bank of Mali) and TBD (Togolese Bank of Development)], their results are comparable but their very bad performances in 2005 and 2006, inflated the standard error.

4. X efficiency evolutions: Non-parametric and parametric methods

In the non- parametric method, X efficiency is represented by pure technical efficiency. The evolutions gotten from this approach are globally more important than those gotten with the parametric method.

Table 11: X efficiency scores comparisons with parametric and non-parametric methods

	Non-parametric	parametric method	
	Evolution	MEAN	Evolution
Country			
Benin	1.1%	0.8085	2.0%
Burkina Faso	3.4%	0.8559	0.7%
Ivory coast	0.4%	0.8740	-2.2%
Guinee Bissau	-14.2%	0.7949	0.1%
Mali	-2.2%	0.7769	-4.0%
Niger	-2.4%	0.7560	-0.9%
Senegal	2.6%	0.8647	-0.7%
Togo	-0.1%	0.6581	-2.7%
WAEMU	-1.4%	0.8143	-1.3%
size			
Small	-0.8%	0.7901	-1.5%
Average	2.0%	0.8052	-1.40%
Big	0.5%	0.8718	-0.80%
Capital structure			
Private	0.7%	0.8242	-1.05%
Semi Private	-0.1%	0.8285	-1.06%
Semi Public	-3.1%	0.6306	-5.94%
Public	3.5%	0.6609	-6.27%

5. Conclusion

The results suggest that the factors global productivity within WAEMU's banks remained *relatively* constant during the period of the survey in spite of a positive technological change. The technological change is about some new means that science puts at the disposal of the banking sector while the technical change is in relation with the manner of which these means are used. Globally the technological change hasn't been incorporated because of scale and technical inefficiencies. The X efficiency remained relatively elevated although having undergone a light decrease. The potential of action of the banks is therefore under used .From the size viewpoint, biggest banks are the most able to support this actual situation while respecting the norms of regulation of the bank commission (minimum capital notably). Ecobank groups proceeded for example to an opening of its capital that now rises at about 1.5 billions of dollars $ to capitalize its African subsidiaries and to finance their expansion. The big banks should increase their hegemony on the banking system. Then the WAEMU zone could benefit from the presence of relatively strong banking and financial institutions, able to stimulate its economic development.

6. References

[1] Aigner, D.J; Lovell, C.A.K.; Schmidt, P. (1977) .Formulation and estimation of stochastic frontier production functions. *Journal of Econometrics*, *6:21--37.*

Allen N. Berger, David B. Humphrey (1997). Efficiency of Financial institutions: International Survey and Directions for Future Research. European *Journal of Operational Research, Vol 98, pp. 175 – 212, 37p*

[2] Battese GE, Coelli TJ (1992) .Frontier production functions, technical efficiency and panel data with application to paddy fanners in India. *Journal of Productivity Analysis 3: 1 S3-169*

[3] Battese GE, Coelli TJ (1993) .A stochastic frontier production function incorporating a model for technical inefficiency effects. *Working Papers in Econometrics and Applied Statistics No 69, Department of Econometrics. University of New England. Armidale*

[4] Battese GE, Coelli TJ (1995) .A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics (1995) 20:325-332*

[5] Bceao (2002 à 2006), Bilans des Banques et Établissements financiers de l'UMOA, *divers numéros, Dakar*

[6] Bceao (2002 à 2007).Rapports annuels, *divers numéros, Dakar*

[7] Bceao (2003, 2004,2006, 2007). Rapports de la commission bancaire de l'UMOA, *divers numéros,Dakar* .

[8] Emili Tortosa-Ausina, Emili Grifell-Tatjé, Carmen Armero ,David Conesa (2002). Sensitivity analysis of efficiency and malmquist productivity indices: an application to spanish savings banks. *Instituto Valenciano de Investigaciones Económicas working paper, WP-EC 2002-30*

[9] Farrel (1957).The Measurement of Productive Efficiency.*Journal of the Royal Statistical Society. Series A (General), Vol. 120, No. 3 (1957), pp. 253-290*

[10] Grifell-Tatje, E., Lovell, C.A.K. (1997).The sources of productivity change in Spanish banking.*European Journal of Operational Research, Vol. 98 pp.364-80*

[11] Joumady, O. (2000). Efficacité et productivité des banques au Maroc durant la période de libéralisation financière : 1990-1996. *17èmes Journées Internationales d'Economie Monétaire et Bancaire Lisbonne, 7-9 juin 2000*

[12] Kablan S. (2007). Mesure de la performance des banques des pays en développement: le cas de l'UEMOA. *Workshop du 2 au 7 Juin*.

[13] Kablan S (2008). Mesure de la performance des banques dans une zone d'ancrage monétaire : cas de la France et des pays de l'UEMOA.

[14] Meeusen W, Van den Broeck J (1977).Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review 18:435-444*

[15] Nguyen Xuan Quang, Bruno de Borger (2008) .Bootstrapping efficiency and Malmquist productivity indices: An application to Vietnamese commercial banks. *A paper submitted to the Asia-Pacific Productivity Conference 2008.*