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Full Length Research Paper

Capacity versus incentive factors explaining research productivity: Comparative and multilevel analysis of Nigeria and Ghana agricultural research systems

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This paper analyzes factors that explain variations in research productivity and outreach among 344 agricultural scientists in Nigeria and 237 agricultural scientists in Ghana using multilevel analysis. Education level, years of experience, and perceived adequacy of funding, physical and human resources are significant capacity actors explaining research productivity. In addition to capacity factors, incentives also showed to be significant in explaining research productivity. Reported staff satisfaction on organizational climate, presence of strong M&E system and presence of flexible-type organizational culture are consistently significant incentive factors explaining productivity. Results revealed that quantity and quality of human resources seem to be the priority for Ghana; while adequacy of physical and financial resources and implementation of organizational management systems seem to be the priority for Nigeria.

Key words: Agricultural productivity, agricultural research, organizational culture, multilevel analysis, Africa.

INTRODUCTION

Improved agricultural technologies and increasing agricultural productivity have been emphasized as key in solving the world's crises in food and natural resource degradation (World Bank, 2007; Food and agricultural Organization (FAO) and World Food Programme (WFP), 2009; International Food Policy Research Institute (IFPRI), 2011). Agricultural researchers and their organizations can play a vital role as innovators to bring forth improvements in agricultural productivity and growth. But despite various attempts by the development partners and other international organizations to strengthen the capacity of researchers and their organizations in many developing countries, various studies find that their productivity, outreach and impact remain low (Eicher,

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2001; IAC, 2004; Clark, 2005). Various reasons that were cited by past studies for the inability of these systems to respond to producer demands and new sectoral challenges and can be summed up into lack of *capacity* (in terms of funding, skill sets, training, education, human resources, infrastructure, and mobility) (Beintema and Stads, 2014; Spielman and Birner, 2008; IAC, 2004; Clark, 2005; Alene et al., 2007) and lack of *incentive* (lack of vision and mission orientation, leadership, different mindsets, different priorities with the organizations, emphasis in outputs and deliverables rather than impact on the ground, low salaries and compensation, and prominence of culture of complacency rather than culture of quality and impact within the organization or research systems (Eicher, 2001; Byerlee 2004; Ragasa et al., 2011). While low adoption and returns can reflect weakness in the agricultural extension system or input distribution system, organizational and institutional bottlenecks at the research organizations can possibly hinder farmers' demand articulation and engagement in research processes and the effective translation of research into useful innovations.

One key area addressed in other fields and relevant to agricultural research is the need to distinguish between *capacity* and *incentive* (Ragasa et al., 2013a, b, 2014) and between organization and institution (Raina, 2003). On agricultural extension, Anderson and Feder (2004) and Ragasa et al. (2013b) indicated the lack of *incentives* of public extension providers as the main cause of the problem. The recognition of the incentive problem has led to various solutions, including privately provided but publicly funded extension (for example, Chapman and Tripp, 2003). On the other hand, there are studies which indicate that lack of *capacity* (that is, inadequate training, knowledge on recent innovations, and lack of proper skills and methods for communication) was the most important reason for the ineffectiveness of extension systems (Bandiera and Rasul, 2006; Feder and Savastano, 2006). On agricultural policymaking processes, Ragasa et al. (2014) showed that both capacity challenges and more so incentive factors are impeding the effective design and implementation of food and agricultural policy and institutional reform processes in the Democratic Republic of Congo. On food safety certification, Ragasa et al. (2013a) showed that incentives (in terms of price differentials in alternative markets) were more important factors in explaining continued certification than capacity of compliance of processing firms in the Philippines. On agricultural research, Raina (2003) stresses the need to distinguish between organizational management systems and institutional reform, which is critical for the effectiveness of both policy and of innovation processes. Organizational management often includes formal structures, such as recruitment policies, staff appraisal systems, and other plans, whereas institutional reform emphasizes organizational values, culture, motivations, and staff accountability. In addition to organizational management constraints, Raina (2003) emphasizes the need to look at institutional constraints that can block the innovation process, as well as sources of motivation that can improve performance.

Therefore, exploring and differentiating between capacities and incentives and between organizational and institutional factors within the research system will contribute to the existing literature at the same time help understand bottlenecks to increasing research productivity and their impact on agricultural productivity.

GHANA AND NIGERIA CASE STUDIES

The cases of Nigeria and Ghana were used because both have had similar significant periods of agricultural policy changes and structural adjustment over the years and are considered two of the largest countries in terms of the size and growth of agricultural R&D expenditures, while still struggling with low productivity and high yield gaps in their major commodities. In terms of their national agricultural research systems (NARS), Nigeria and Ghana are two of the biggest in sub-Saharan Africa (SSA), contributing 24 and 4%, respectively, to the continental funding of 1.7 billion dollars in 2011 (raw data from Beintema and Stads, 2014). We choose these two countries to enable comparison of the two biggest R&D systems in SSA, and also because funding for the data collection and analysis for this paper was available for these countries. The socioeconomic indicators for Nigeria and Ghana are shown in Table 1.

The public agricultural research systems in both countries are structured similarly, although Nigeria is substantially larger and more complex in terms of size and number of institutions involved. In Nigeria, there are 15 agricultural research institutes and 11 federal agricultural colleges under the umbrella organization, Agricultural Council of Nigeria (ARCN), and a significant number of agricultural higher education agencies conduct agricultural research at both federal and state levels (including 122 specialized universities, colleges, faculties, and departments based on latest estimate by ASTI). In Ghana, 30 public agencies conduct agricultural research – 10 agricultural research institutes are under the main government umbrella research organization, Council for Scientific and Industrial Research (CSIR), Cocoa Research Institute of Ghana (CRIG), which conducts research on tree crops (cocoa, coffee, kola, and cashews), Marine Fisheries Research Division, which focuses on marine fisheries, and 18 universities and colleges.

The government remains the largest contributor to public agricultural research in both countries, although in more recent years, greater proportion of donor contribution

Table 1. Summary of socioeconomic statistics and description of the agricultural research systems in Nigeria and Ghana.

Indicators	Nigeria	Ghana
Social and economic indicators		
Population (2010)	158,258,917	24,332,755
Poverty headcount ratio at national poverty line (% of population) (2009)*	64.4%	35.5%
GNI per capita US$ (2010)	1,180	1,240
Life Expectancy in years (2009)	48	57
Literacy Rate (% of population) (2009)	61	67
GDP growth rate* (2009)	2.9%	4.5%
Malnutrition rates* (2009)	28.7%	13.9%
Share of agriculture in GDP	33% (2006-2007)	31% (2006-2009)
Percentage of agricultural investment to total public expenditure* (2009)	4.5%	5.8%
Ratio of agricultural investments to AgGDP* (2009)	<5%	<2%
AgGDP growth rate* (2009)	-0.3% (2009)	4.5% (2009)
Agricultural research system**		
Number of technology produced (1997-2008)	207	106
Ratio of technology produced (1998-2008) to total number of researchers [FTE] (1990-2005) (Technology/researcher)	6	4
Number of researchers ([FTE] (2008)	2062	537
Number of researchers ([FTE] (1990-2005)	1,250	390
Number of rural population per FTE researcher	39,300	21,800
Agricultural research expenditure (million PPP dollars) [2008]	392	95
Agricultural research expenditure (million PPP dollars) [1990-2005]	170	38
Agricultural research expenditure (% of AgGDP) (2008)	0.40%	0.53%

Source: World Bank - http://data.worldbank.org/country/ (accessed 3rd Sept. 2011) if not specified; *Omilola and Lambert (2010). **Ragasa et al. (2011).

is observed in Ghana compared to Nigeria. In Ghana, 8 to 14% of total funding were from donor contributions from 2009 to 2011, while only 1% in 2009 and none in 2010 to 2011 in Nigeria. In both countries, there has been substantial increases in total government research funding in the 2000s in contrasts to stagnating funding in the 1990s. Despite more erratic funding owing to a historical backdrop of unstable governance and institutions in Nigeria, some improvements are observed. Nigeria has been relying less on donor funding in recent years. Nigeria has been allotting greater proportion of funding for capital expenditure in more recent years (10 to 21% in 2009 to 2011) while Ghana persistently has the highest proportion of its total research expenditure for salaries and none for capital expenditure (76 to 81% in 2009 to 2011). Both countries have instituted a series of NARS reforms, but have limited documentation and evidence of their effectiveness or the responsiveness of their research institutions to the needs of poor farmers. For example, while there is strong agricultural output growth (4.6% from 1991 to 2009) that has played an important role in Ghana's development, much of this growth has been due to the expansion of cultivated areas rather than increases in productivity, indicating limited impact of decades of research investment. Total factor productivity (TFP) growth has averaged only 1.2% annually for Ghana during the period from 2001 to 2009 - higher than the African average of 0.5%, but below the global average of 1.8% (Fuglie, 2012). While Nigeria's agricultural output and TFP growth in the 1990s have been higher than average in SSA and the world, its agricultural output and TFP growth after the 1990s have been far lower than the global average and even lower than the SSA average, indicating the limited impact of decades of research investment in Nigeria.

This paper aims to provide a better understanding of factors contributing to limited productivity and impact of agricultural researchers and research organizations. This remains a large gap in the literature. We take advantage of the differences across organizations within each country to provide insights as to what organization and institutional factors contribute to improving organization performance. We also explore the differences between individual researchers within the organizations and across organizations within the country to provide insights on the organizational and institutional factors that contribute to improving individual productivity and research outreach. Our results show that in addition to

individual characteristics, organizational and institutional factors are statistically significant in explaining research productivity. Both capacity and incentive factors play a role in explaining research productivity across various research organizations in Ghana and Nigeria. In this paper, the evidence for this conclusion is presented. First, the measures and definitions of performance in agricultural research system and factors that explain it was presented based on the literature review. In the next section, the materials, data sources and analytical methods used are discussed. Then, the main results are presented and the implications discussed. Lastly, conclusion is drawn with key messages for Nigeria, Ghana and wider research and development community, and future research agenda.

LITERATURE REVIEW AND FRAMEWORK

This paper combines elements of organizational design and collaboration-scientific productivity linkages (Peterson et al., 2003; Duque et al., 2005; Lee and Bozeman, 2005); conventional agricultural research productivity analysis (Bantilan et al., 2004); institutional theory and public-sector motivation literature (Manning et al., 2000; Raina, 2003); and agricultural innovation systems perspective (Hall et al., 2003; Spielman and Birner, 2008) to measure and explain variations in researchers' and their organizations' performance. Figure 1 shows the conceptual framework of the different factors explaining individual and organizational performance.

Measuring and defining performance

Organizational performance - the focus of this study - is measured using four sets of indicators drawn from the literature: (1) conventional measures of research productivity, including quantification of technology developed and publications produced at a given time (Peterson et al., 2003; Bantilan et al., 2004); (2) agricultural innovation systems indicators emphasizing connectivity and linkages among various innovation actors, and measures of use and impact of innovations generated by the system (Hall et al., 2003; Spielman and Birner, 2008); (3) dissemination of research outputs; and (4) technology adoption.

Technology involves all new varieties or new breeds that were developed by researchers (together with other staff) and were registered or released in the last five years (2005 to 2009), and including biological, chemical, and mechanical technologies and improved production, management, conservation, and marketing practices. Publications include books, book chapters, and other peer-reviewed publications (particularly scholarly articles in international and national scientific journals), published as first author or coauthor in the last three years (2007 to 2009). Due to limited availability of international databases of locally produced journals and books in many developing countries, this paper relied on self-reported number of publications and technologies verified through their CVs and organization heads.[1]

Innovation system indicators include presence of any interaction or linkages with other actors; the frequency of interactions with other innovation actors and end-users, and the satisfaction by researchers on the benefits of these interactions. These linkages and interactions were asked both at the level of organizations (whether the organizations has formal and informal linkages with other organizations and individuals) and at the individual researcher's level (whether individual researchers have external collaborators) in developing their publications and technologies. While research collaboration can improve productivity, several empirical studies (Dugue et al., 2005; Lee and Bozeman, 2005) show that they are not necessarily and statistically linked. However, external collaborators could bring other intangible benefits such as greater knowledge and exposure, staff morale, greater social capital, and better likelihood of publication use and technology uptake that cannot easily show up and be captured in publications and technologies generated within a given short period. For these reasons, we also included external collaboration on publications and in technology development as one of the outcome variables. In addition, indicators were used on linkages at the organizational level as explanatory variables explaining quantity of publication and technology generated and adoption levels.

Other outcome variables measured and used are the number of dissemination events, defined as the number of conferences, seminars and meetings where research results and findings from the reported publications were presented and disseminated. Lastly, researchers were asked about the adoption level of the technologies they produced, together with other staff in the organizations. An indicator of the knowledge and awareness of any evaluation or adoption rate of technologies produced is also included. Table 2 shows the descriptive statistics of the different outcome variables used in this paper.

Factors explaining performance

Performance can be explained by capacity and incentive factors at the individual and organization levels. Commonly

[1] To minimize the bias in self-reporting, the questionnaires were kept anonymous and confidential, which was emphasized to the respondents. It was emphasized by the organization heads and interviewers to answer the questions as honest and accurately as possible to help analyze important factors on how productivity and performance can be improved. Organization heads also helped verified the accuracy of the responses of the survey respondents. In most cases, CVs were requested to be printed, so that respondents will find it easier in answering the questionnaires and minimize errors in self-reporting. It was also emphasized that the survey will help in identifying areas of capacity strengthening with the aim of minimizing any overstatement of accomplishments in terms of technologies and publications produced.

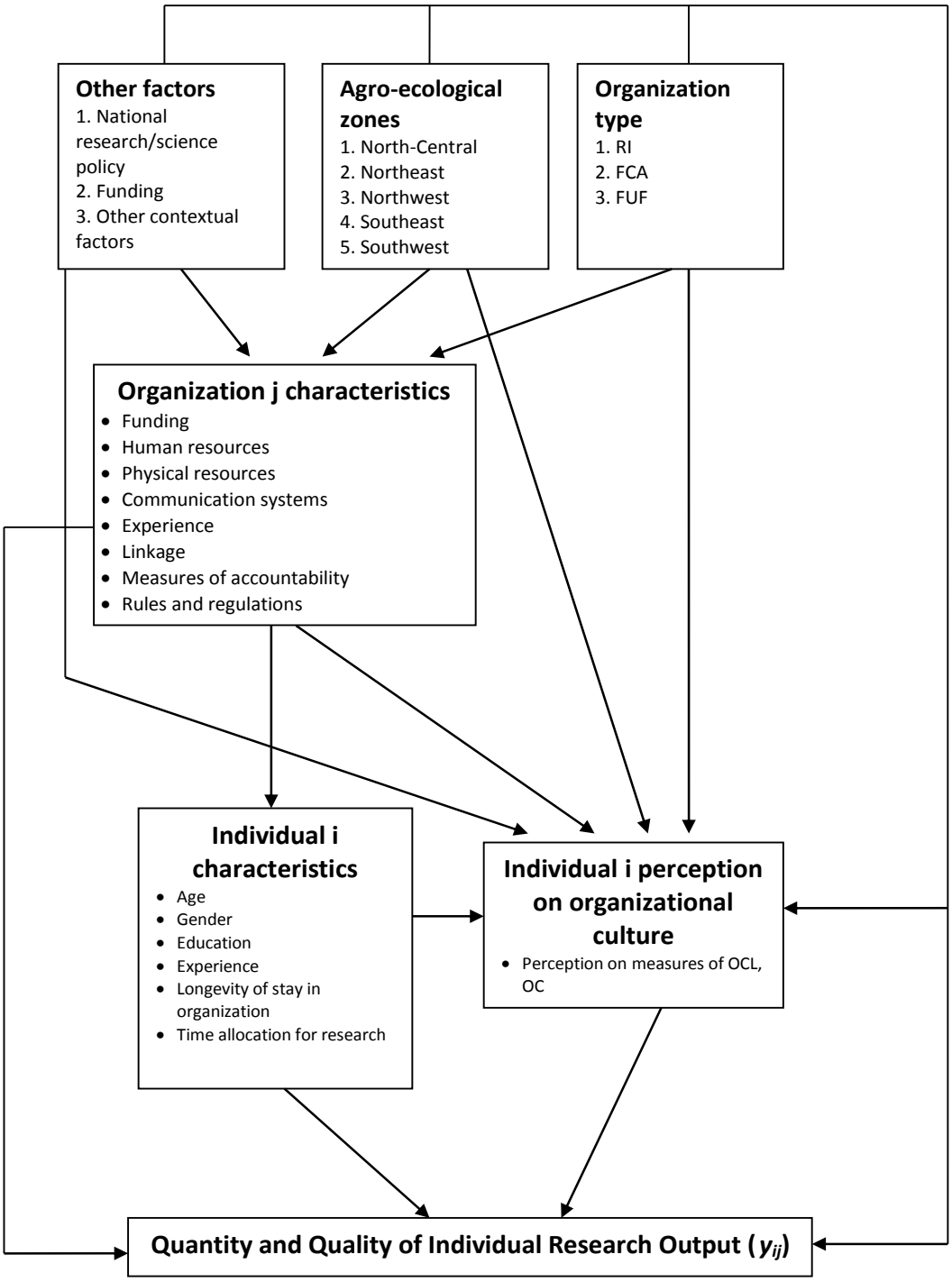

Figure 1. Framework for modeling individual and organizational characteristics to explain researcher performance. Source: Authors. Note: RI=Research institutes; FCA=federal colleges of agriculture; FUF=faculties of agriculture or veterinary medicine at federal universities. OCL=Organizational climate; OC=Organizational culture.

significant individual characteristics include age, gender, education, discipline, experience, position or job classification, linkages and affiliations, and reputation (Gulbrandsen and Smeby, 2005; Gonzalez-Brambila and Veloso, 2007; Manjarres-Henriquez et al., 2009; Abramo et al., 2009; Ponomariov and Boardman, 2010; Costas et

Table 2. Descriptive statistics of agricultural researcher's output and other outcome variables, Nigeria and Ghana, 2010.

Outcome variables	Nigeria				Ghana			
	Ave.	SD	Min	Max	Ave.	SD	Min	Max
Technology produced (2005-2009) (count data)	0.76	2.22	0.00	22.00	2.27	3.51	0	21
Publication (2007-2009) (count data)	8.28	10.09	0.00	25.00	3.63	5.43	0	21
With international collaborator in producing publication (dummy)	0.37		0.00	1.00	0.49		0	1
With national collaborator in producing publications (dummy)	0.78		0.00	1.00	0.77		0	1
Number of dissemination events (count data)	5.03	4.01	0.00	52.00	4.20	5.04	0	40
With international collaborator in developing technologies (dummy)	0.29		0.00	1.00	0.32		0	1
With national collaborator in producing technologies (dummy)	0.51		0.00	1.00	0.39		0	1
With knowledge on the adoption level of technologies produced (dummy)	0.38		0.00	1.00	0.20		0	1

Source: IFPRI-ARCN survey (May-July 2010) and IFPRI-STEPRI survey (May-July 2011).

al., 2010 for more recent studies). The findings in the literature for these factors are summarized in Table 3 and the descriptive statistics are in Table 4.

While many studies have analyzed individual capacity factors, there is dearth of studies that look at individual incentives. This paper aimed to add to the literature by using various indicators to capture individual-level incentive factors. First, time devoted to research was used, which proxies the organization's mission, orientation and incentives toward doing research compared to other work. Second, staff satisfaction or rating on salary and compensation at the individual level was used (perceived competitiveness of salaries and adequacy of salaries relative to living expenses). Since there is no data of individual salary levels, organizational-level salary costs per full-time equivalent was used as another measure of financial incentives. Third, individual score or rating on organizational climate were collected and used (OCL). OCL can also be thought of as related to the concept of staff morale or staff satisfaction discussed by Manning et al. (2000) or the institutional factors emphasized by Raina (2003) as important consideration in studying agricultural research organizations. Authors such as Gregory et al. (2009) and Henri (2006) used a wider classification of OCL combining measures of transparency, fairness, political autonomy, coherence, mobility, openness, responsiveness, flexibility, participatory leadership, adequacy of resources, and employee morale or satisfaction. In this paper, this classification of OCL was used and 20 questions were utilized which reflected survey respondents' perception on the organizational climate in their respective organizations. Survey respondents were asked to rate using Likert scale (scale from 1 to 4; 1 being the most conducive) their satisfaction on transparency, fairness, political autonomy, coherence, mobility, openness, responsiveness, flexibility, participatory leadership, and adequacy of resources in the organization and their employee morale or satisfaction of the organization overall. An overall index generated from factor analysis was used to capture these 20 different indicators of organizational culture. Table 4 shows the descriptive statistics of these indicators.

At the organization level, only a few studies have investigated organizational factors. Among them, Gulbrandsen and Smeby (2005) showed that funding received by organization appeared to be significant in explaining research output. Bonaccorsi and Daraio (2003) performed an efficiency analysis using biometrics data as output and found location and geographical agglomeration to be significant in determining research outputs in French institutes but not in Italian institutes. Lorenz and Lundvall (2010) showed that creative employees were over-presented in business services and social and community services than in manufacturing, construction, and utilities. The authors showed that institutional and national context had a significant direct impact on the individual creativity at work across 27 European research organizations.

This paper aimed to add to the literature by using various indicators to capture organization-level factors. In terms of organizational-level capacity factors, staff's satisfaction or rating on the adequacy of funding, human resources, communication system, physical resources (that is, research facilities and infrastructure), and extent of organizational linkages was used. Survey respondents were asked to rate adequacy of resources, systems or linkages using a scale of 1 to 5, with 5 being the highest or most preferred. To ensure that these organizational characteristics correspond to the period when publications and technologies were produced, survey respondents were asked to rate the conditions of resources and systems in the last 5 years, instead of their conditions today.

In terms of organization-level incentive factors, three indicators were used. First, staff's satisfaction or rating were requested and used on the monitoring and evaluation system of the organization. Second, the scores of OCL of individual staff were averaged (as described above) to make an organization-level indicator

Table 3. Hypothesized factors explaining research productivity, and summary of significance of these factors in this paper

Factors	Related literature	Hypothesis	Results in this paper
Individual level			
Capacity			
Education	Gonzalez-Brambila and Veloso (2007) use three different break points associated with three different cohorts (namely the early-educated group of researchers, the middle years, and the latest educated) and find no significant difference between the first and the latest educated and that the second cohort is slightly more productive than the latest educated.	+	Education is positively related to number of publication, technology, international and national research collaboration, dissemination events in both countries and international technology collaboration in Nigeria
Gender	Female researchers tend to publish less compared to male researchers (Gonzalez-Brambila and Veloso, 2007; Turner and Mairesse, 2003; Xie and Shauman, 1998; Cole and Zuckerman, 1984). Ponomariov and Boardman (2010) find gender not significant.	Female (-), due to social norms, more limited opportunities, and more severe time burden	Mixed results, no consistent evidence that female researchers have less research productivity. Female researchers have fewer publications and fewer technologies in Nigeria and fewer dissemination events in Ghana, but they have greater number of publications in Ghana.
Reputation or experience	Gonzalez-Brambila and Veloso (2007) find that reputation (measured in terms of 10-year stock of publication and citations) is positively related to research output.	Good reputation (+); more experience (+)	No available data on reputation and experience. Bu we used proxies such as years since latest degree and years in the organization. We find mixed results in this paper.
Funding received	Gulbrandsen and Smeby (2005) found that size, structure, and source of funding received by researchers are significant factors in explaining researchers' outputs.	+	No available data at individual researcher's level but there is data at organization level (see below)
Incentive			
Time allotted for research		+	Mixed results
Individual salary		+	Not significant
Individual perception on organizational climate (OCL)	OCL can affect employee satisfaction (Gregory et al. 2009); staff turnover (Stone et al., 2007); motivation of staff and managers (Moynihan and Pandey, 2007); extent of knowledge sharing (Willem and Buelens, 2007); organizational performance and effectiveness (Ogbonna and Harris, 2000); and the diversity and nature of use of performance measure systems (Henri, 2006)	Conducive organizational culture (+)	
Both capacity and incentive			
Age	Costas and van Leeuwen (2010) shows that top-publishing scientists in the Spanish National Research Council are the youngest within each professional category.	Quadratic relationship	Quadratic relationship between age and number of publication in Nigeria and number of dissemination events in Ghana
Age squared	Gonzalez-Brambila and Veloso (2007) find a quadratic relationship between age and the number of publications of a researcher		
Organizational level			
Capacity			
Organization's funding	Gulbrandsen and Smeby (2005) find + relationship with research output	+	+ in most models for Nigeria
Adequacy of human resources		+	+ in most models for Ghana

Table 3. Contd.

Adequacy of communication system		+	+ in most models for both countries
Adequacy of physical resources		+	+ in most models for Nigeria
Organizational linkages		+ (more connections, more resources, more opportunities)	Mixed results; mostly not significant
Location	Bonaccorsi and Daraio (2003) perform an efficiency analysis using biometrics data as output and find that location and geographical agglomeration to be significant in determining research outputs in French institutes but not in Italian institutes	significant (due to spillover effect and infrastructure and policies available in certain locations)	
Incentive			
M&E system		+	+ in most models for Nigeria
Perception on organizational climate (OCL)	OCL can affect employee satisfaction (Gregory et al. 2009); staff turnover (Stone et al. 2007); motivation of staff and managers (Moynihan and Pandey 2007); extent of knowledge sharing (Willem and Buelens 2007); organizational performance and effectiveness (Ogbonna and Harris 2000); and the diversity and nature of use of performance measure systems (Henri 2006)	Conducive organizational culture (+)	Significant in most models for both countries
Type of organizational culture	Quinn and Rohrbaugh (1983) and Gregory et al. (2009) have done empirical work on organizational culture and results are mixed. Most studies show that control-type OC are linked to less creativity and productivity.	Control-type (-)	Control-type (-)
Both capacity and incentive			
Type of organization	Lorenz and Lundvall (2010) show that creative employees are over-presented in business services and social and community services than in manufacturing, construction, and utilities.	significant (as it may dictate the type of funding, policies and/or incentive systems)	
Institutional or national context	The authors show that institutional and national context have a significant direct impact on the individual creativity at work across 27 European research organizations.	significant (as it may dictate the type of funding, policies and/or incentive systems)	

Source: Compiled by authors from various studies.

for OCL. Third, types of organizational culture (OC) were used - classified into (1) flexible-dominant and group-oriented type; or (2) control-dominant and hierarchical-oriented type - as another indicator. OC represents "the collection of traditions, values, policies, beliefs and attitudes that constitute a pervasive context for everything done and thought in an organization" (Marshall and McLean, 1988: 32). Gregory et al. (2009) carried out an empirical work on organizational culture using a "competing values" model that incorporates two sets of competing values within the organizations: (1) the *control* versus *flexibility* dilemma, which refers to preferences about structure, stability, and change, and (2) the *people* versus *organization* dilemma, which refers to differences in organizational focus. Therefore, OC is reflected in the degree of control or flexibility, and inward and outward orientation, focus, and leadership type in the organization. These authors emphasize that the absence of any dominant type, that is balanced culture type, is the most preferred and most effective type, and it is still subject to empirical research whether control-versus

Table 4. Descriptive statistics of capacity and incentive factors of sample individual agricultural researchers, Nigeria and Ghana, 2010.

Variable	Nigeria		Ghana
Capacity factors			
Highest level of education			
BSc	11		5
MSc	40		55
PhD	49		40
Dummy for gender (1=FEMALE)	**0.31 (0.46)**	/a	**0.20 (0.40)**
Number of years after last degree			
< 1 year	6		9
1-4 years	34		23
5-7 years	22		24
8-10 years	12		10
> 10 years	26		34
Number of years in the organization			
< 1 year	5		7
1-4 years	10		17
5-7 years	18		11
8-10 years	22		9
> 10 years	45		55
Incentive factors			
Percentage of time allocated to research	**39.76 (21.80)**	/a	**53.17 (23.61)**
Satisfaction with salary and compensation (1-5 scale, 5 is the most preferred)	**1.88**		**1.97**
Individual score for organization climate (1-4, 1 is the most preferred)	**2.2**		**2.08**
Both capacity and incentive			
Age group			
≤ 20	3	/b	0
21-30	5		6
31-40	38		27
41-50	37		35
≥ 51	17		32

Source: IFPRI-ARCN survey (May-July 2010) and IFPRI-STEPRI survey (May-July 2011). Note: /a Figures represent the mean and the ones in parentheses are the standard deviation. /b Percentage to total respondents per category.

flexible-dominant culture type is more effective. The findings in the literature for these factors are summarized in Table 3 and the descriptive statistics are in Table 5.

MATERIALS AND METHODS

Data source

The data and information used in this paper were collected using multiple sources. A total of 344 agricultural scientists in Nigeria and 237 agricultural scientists in Ghana were interviewed through a face-to-face survey using computer-assisted personal interview mobile device jointly conducted by IFPRI and the Agricultural Research Council of Nigeria (ARCN) in Nigeria between May and July, 2010 and jointly conducted by IFPRI and the Science and Technology Policy Research Institute (STEPRI) in Ghana between May and July, 2011. This survey was complemented by key informants' interviews and review of relevant literature.

In Nigeria, a total of 47 relevant public-sector organizations involved in agricultural research were interviewed, including all 15 of ARCN's agricultural research institutes, all 11 federal colleges of agriculture (FCA), and 21 of 48 faculties of agriculture and veterinary medicine in federal universities (based on the willingness of organizations to participate and respond to the survey). In Ghana, a total of 16 public-sector organizations involved in agricultural research were interviewed, including all nine agriculture-related research institutes under Council for Scientific and Industrial Research (CSIR); one of three relevant non - CSIR research centers, the Cocoa Research Institute of Ghana (CRIG), based on the willingness of organizations to participate in and respond to the

survey; and six of 15 faculties of agriculture in public universities identified by Science and Technology Policy Research Institute (STEPRI) and ASTI (Flaherty et al., 2010). Despite the limited sample of agricultural education institutes and relying on the willingness of organizations to respond to the survey, ex post analysis of the sample organizations reveal that the larger agricultural education institutes in Nigeria were covered and, therefore, the dataset should be interpreted as those covering the larger agricultural education institutes and does not represent those smaller ones. In Ghana, the larger agricultural universities are covered, except University of Cape Coast. However, further investigation reveals that agriculture research and the level and nature of agricultural technology development in UCC would be similar to that of other larger universities included in the sample. Therefore, for both Nigeria and Ghana, the dataset could be interpreted to include all agricultural research institutes and represents larger agricultural education institutes in those two countries.

Face-to-face surveys of a range of 3 to 20 randomly selected staff per organization were then conducted by the IFPRI–ARCN–STEPRI teams. The actual sample size was based on the total number of research staff (for example, a range from 26 to 140 research staff in research institutes and a range from 5 to 214 staff conducting research in universities in Nigeria; and a range from 10 to 77 research staff in research institutes and a range from 5 to 29 staff working on research in universities in Ghana). Research staff was selected from each organization's nominal roll or list of research staff, stratified into top management, middle management, and junior research staff. For smaller organizations, one staff in each of the strata was selected randomly; while larger organization had 2 to 7 staff in each of the strata randomly selected depending on the size of the organization. In Nigeria, a total of 344 sample researchers were interviewed out of 3,920 individual researchers (9%). In Ghana, out of a total of 706 researchers, 237 individual researchers were randomly selected and interviewed (33%).

Two sets of questionnaires were used - one questionnaire for organizations, to be answered by organization heads or a designated representative, and another for individual researchers. The questionnaire for organizations included questions on the organization's mission; research management issues and training needs; scientific and technical training needs; the availability of physical and human resources; research outputs; management systems and procedures; partnerships and linkages; accountability and motivations; and funding sources. The questionnaire for individual researchers covered demographic and individual characteristics; research outputs; workload; linkages; research issues and training needs; motivation and incentives; and perception of the organization's culture.

Analytical method

This paper utilized a multi-level analysis following a conceptual framework presented in Figure 1. Multi-level modeling allows to model processes at multiple levels of the population hierarchy. By simultaneously modeling at multiple levels it is possible to determine where and how effects are occurring (Lorenz and Lundvall, 2010; Rasbash et al., 2005; Goldstein, 2003). Multilevel modeling also responds to the criticism often made of single-level models that too much emphasis is placed on individual's characteristics and neglect the social, institutional, or organizational context (Lorenz and Lundvall, 2010; Rasbash et al., 2005; Goldstein, 2003). Failure to take into account the hierarchically structured nature of the data may lead to serious technical problems, with standard errors of the regression coefficients being underestimated.

The analysis of research productivity operates at two levels, with individual employees at level-1 being clustered within organization at level-2. The variables characterizing employees at level-1 are derived from the individual responses to IFPRI-ARCN and IFPRI-STEPRI individual-level survey questionnaire; while variables characterizing the organizational context at level-2 are derived from the IFPRI-ARCN and IFPRI-STEPRI organization-level survey questionnaire administered with heads or designated representative of organizations. In a simple two-level model, the linear predictor with random intercept and coefficient for organization *j* is given as:

$$\eta_{ij}(y_{ij}) = \sum_{l=1}^{k} x_{ij}\beta_{lj} + \upsilon_{lj} \quad (1)$$

Where η_{ij} is the linear predictor (with represents a functional form of the model); y_{ij} is the outcome variable; x_{ij} is the vector of covariates with fixed effects or the standard coefficient β and $\beta = (\beta_{1j}, \beta_{2j}, \ldots, \beta_{kj})$ are unknown *k*-dimensional column vector of coefficients; the subscript *i* represents the individual scientists (level-1 units), and subscript *j* represents organizations (level-2 units); and υ_{lj} is the random effect (one for each organization). These random effects represent the influence of organization *j* on individual *i* that is not captured by the observed covariates. These are treated as random effects because the sampled organizations represent a population of organizations, and they are assumed to be distributed as $\mathcal{N}(0, \sigma_v^2)$.

Since several measures of research output (y_{ij}) are being used with varying structure and nature of the data (Table 2), different functional forms or models are employed for estimation in this paper. For the number of publication and number of dissemination events for publications, characterized as over dispersed count data variables, this paper uses the generalized Poisson regression (GPR).[2] The generalized Poisson regression (GPR) model $f(\mu_i, \alpha; y_i)$ is adopted from Famoye and Singh (2006) and is given by:

$$f(u_{ij}, \propto; y_{ij}) = \left(\frac{\mu_{ij}}{1+\propto\mu_{ij}}\right)^{y_{ij}} \frac{(1+\propto y_{ij})^{y_{ij}-1}}{y_{ij!}} exp\left[\frac{-\mu_{ij}(1+\alpha y_{ij})}{1+\alpha\mu_{ij}}\right] \quad (2)$$

Where the mean of y_{ij} is given by $\mu_{ij}(x_{ij}, \upsilon_j)$ and the variance of y_{ij} is given by $V(y_{ij} \mid x_{ij}, \upsilon_j) = \mu_{ij}(1 + \alpha\mu_{ij})^2$; and α is the dispersion parameter. For the number of technologies produced, counting data with excess zeros, this paper uses a zero-inflated generalized poisson (ZIGP) model adopted from Famoye and Singh (2006) and is given by:

$$P(Y = y_{ij} \mid \upsilon_i, x_{ij}, z_{ij}) = \varphi_{ij} + (1 - \varphi_{ij})\, f(\mu_{ij}, \alpha; 0), \quad y_{ij} = 0$$

$$= (1 - \varphi_{ij})\, f(\mu_{ij}, \alpha; 0), \quad y_{ij} > 0 \quad (3)$$

Where $f(\mu_{ij}, \alpha; y_{ij})$, $y_{ij} = 0, 1, 2, \ldots$ is the GPR model in equation (2); $0 < \varphi_{ij} < 1$; x_{ij} represents the set of covariates affecting μ_{ij}; and z_{ij} represents the set of covariates affecting φ_{ij}. The model in equation (3) reduces to the GPR model when $\varphi_{ij} = 0$. For positive values of φ_{ij}, it represents the zero-inflated generalized Poisson regression model.

[2] An alternative is negative binomial regression (NBR) model which assumes that $\sigma^2 > 1$, so that there cannot be underdispersion. Generalized Poisson Regression (GPR) allows for all types of dispersion. GPR has been a good competitor of NBR and in some instances, it may also have some advantages (Famoye and Singh 2006). In the Famoye and Singh (2006) paper, they successfully fitted the ZIGP regression model to all datasets, but in a few cases, the iterative technique to estimate the parameters of ZINB regression model did not converge. Moreover, GPR has an edge over NBR for estimating parameters of the conditional mean (Wooldridge 2002).

For the dummy variables representing presence of at least one international or national research collaborator and knowledge and awareness of adoption level of technologies produced, binary response variables, the paper uses logit regression model with response probability (Equation 4) and logit link (Equation 5) given as:

$$p(x_{ijl}) \equiv P(y_{ij} = 1|\, v_{il}; x_{ijl}\,) = P(y_{ij}^{*} > 0|\, x_{ijl}\,) = \frac{\exp(\sum_{l=1}^{k} x_{ijl}\beta_{lj} + v_{lj})}{1+\exp(\sum_{l=1}^{k} x_{ijl}\beta_{lj+v_{lj}})} \quad (4)$$

$$\eta_{ij} = \Lambda(\sum_{l=1}^{k} x_{ijl}\beta_{lj}) = logit(\pi_{ij}) = log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \sum_{l=1}^{k} x_{ijl}\beta_{lj} + v_{lj} \quad (5)$$

Where y^{*} is a latent variable determined by $y^{*} = \sum_{l=1}^{k} x_{ijl}\beta_{lj} + e, y = 1[y^{*} > 0]$, e is the disturbance term; π_{ij} is the underlying probability that *y=1*; and Λ is the logit model.

The types of organizations (research or higher education institute) are controlled in the models: whether they are in research institutes (RI), where researchers are expected to do mainly research; federal colleges of agriculture (FCAs), which are linked to the RIs and staff are expected to do research, training, and outreach activities; and federal universities, where staff are expected to do mainly teaching and part-time research and outreach.. The GLLAMM command in STATA was used in modeling and adaptive quadrature was utilized to perform the integration over random-effects distribution.

Econometric issues

Two potential econometric issues are considered: heterogeneity and endogeneity. For example, good researchers tend to work at the best institutions, if they can choose where to work. The organizational variables can be contemporaneous with the outcome variables if measured in the same period in which the scientific output is measured, and therefore the organizational variables cannot explain the scientific output. It is likely that the factor that explains the scientific performance can also explain the organization characteristics, hence the organizational characteristics are endogenous in the model.

These issues could have been best addressed by having a panel dataset. Given that our dataset is cross-section and not a panel one, we address these issues by the following considerations. First, to ensure that the organizational characteristics correspond to the period when publications and technologies were produced, survey respondents were asked to rate the conditions of resources and systems in the last 5 years, instead of their conditions today or in the previous couple of years. Second, there was control for several factors that explain observed heterogeneity in the data, for instance, type of organization, location, and time allotted for research. Third, a model was run which explained OCL index, a variable that describes organizational features and may be correlated with exogenous variables that do not directly explain research productivity. Several potential instruments were tried to address endogeneity issue. For the instruments to be valid, the F-statistics of the instruments in the first-stage regression should be significant and not in the second regression (Di Falco et al., 2011) or the instruments are statistically correlated with OCL index but not statistically correlated with the error term in the second equation (with publication and technology as the outcome variables) (Lee and Bozeman, 2005). The valid instruments that qualified based on this criterion include the agro-ecological zone where the organization's headquarters is located, whether the organization is officially under the ministry of agriculture or education, reasons why the individual staff chose the job, and the individual's perception on the central goal of the organization. OCL index was tested to be endogenous and therefore we used the predicted value of OCL index from the first equation modelling into the second equation explaining the different outcome variables (technology, publication, collaboration, dissemination events and knowledge of adoption levels).

Limitations of the study

While this paper provides useful insights and policy implications, it is constrained by several limitations of data. First, emphasis was that despite the considerations to address heterogeneity and endogeneity in the econometrics, the results on the coefficients of the explanatory variables should be interpreted as associations or correlates rather than as casual effects or impacts.

Second, the dataset used in this study include small number of observations per organization (3 to 15 researchers per organization) although they were selected randomly and experts' opinion suggests that the sample is representative.

Third, measures of research output are based on self-reported values. Anonymity of the responses was important to the research design due to the possible sensitivities of the responses in perceptions. Moreover, locally-produced journals and publications in Nigeria and Ghana and in other developing countries are often not comprehensively available in international databases and search engines. For these reasons, this paper used self-reporting rather than bibliometrics data, but several measures have been implemented to ensure that bias of self-reporting were and verifications were made. To minimize the bias in self-reporting, the questionnaires were kept anonymous and confidential, which was emphasized to the respondents. It was emphasized by the organization heads and interviewers to answer the questions as honest and accurately as possible to help analyze important factors on how productivity and performance can be improved. In most cases, resumes were requested to be printed, so that respondents will find it easier in answering the questionnaires and minimize errors in self-reporting. It was also emphasized that the survey will help in identifying areas of capacity strengthening and not an evaluation of efforts or performance which likely minimized incentive to over-report.

Fourth, indicators on outreach of publications and technologies produced have been included, and is an improvement to just reporting on research outputs. In addition, publications and technologies were disaggregated by type for comparability. For publications, the analysis was disaggregated into books and book chapters, international journals, and national journals. For technologies, the analysis was disaggregated into varieties or biological technologies, mechanical technologies, chemical technologies, and management practices. While these are value additions of the paper, alternative measures can be explored. While this study measures presence of external collaborator, extent of dissemination, and extent of knowledge and awareness of adoption levels, it does not include measures of impact of these publications due to the inherent difficulty of measuring research. While this study is innovative in including a measure of perceived adoption levels of technologies produced, it does not include a more objective and actual adoption rates of these technologies.

RESULTS

The results of the various models estimated suggest that

Table 5. Descriptive statistics of capacity and incentive factors of sample agricultural research organizations, Nigeria and Ghana, 2010.

Categories	Nigeria		Ghana	
	Ave.	SD	Ave.	SD
Capacity factors				
Funding				
Satisfaction with organizational funding (1-5 scale)	1.98	1.84	2.01	1.00
Human resources				
Satisfaction [1] with human resources (1-5 scale)	2.81	0.97	2.60	0.95
Communication system				
Satisfaction[1] with the adequacy of ICT (1-5 scale)	2.28	0.99	2.01	1.00
Physical resources				
Satisfaction[1] with the adequacy of laboratory and research facilities (1-5 scale)	2.3	1.08	2.18	1.00
Satisfaction[1] with the adequacy of computers (1-5 scale)	1.7	0.69	2.12	1.09
Organizational linkages				
With international linkages (dummy)	0.32	0.47	0.75	0.44
With linkages with training institute (dummy)	0.38	0.49	0.38	0.5
With linkages with research institute (dummy)	0.66	0.48	0.75	0.44
With linkages with universities or colleges (dummy)	0.40	0.50	0.88	0.34
With linkages with private sector (dummy)	0.17	0.38	0.5	0.52
Incentive factors				
Satisfaction[1] with M&E system (1-5 scale)	1.98	1.84	3.54	0.52
Average rating on organizational climate				
Perception on Organizational climate (1-4 scale; 1 being the most preferred)	2.2	0.45	2.08	0.33
Dominant organizational cultural types				
Flexibility-dominant type (dummy)			69	(percentage)
Control-dominant type (dummy)			31	(percentage)

[1] As perceived by the head or representative of the organization interviewed; with scale 1 (not satisfied) to 5 (very satisfied). Source: IFPRI-ARCN survey (May-July 2010) and IFPRI-STEPRI survey (May-July 2011).

both individual characteristics and organizational factors are statistically significant in explaining research productivity of individual staff in the sample organizations in Nigeria and Ghana. Moreover, various indicators of capacity and more so of incentives are significant. However, there are major differences in the statistical significance and direction of correlation of these factors between Ghana and Nigeria and depending on the measures of research output quantity and outreach used. Summary tables of results are in Tables 6 to 8. The goodness-of-fit measures of the logit models indicate that the selected explanatory variables explain most of the variations of the outcome variables; while the insignificance of the Pearson goodness-of-fit tests of the poison models indicate that the model specification selected are appropriate (Tables 6 to 8).

Publication

In terms of individual capacity, it is consistent that education is a highly significant factor in explaining individual productivity in both countries. This seems to be consistent with past studies. Length of stay in the organizations (proxy of experience and familiarity in the organization) is also consistently significant. Gender is also significant, but of different signs between Nigeria and Ghana. Female researchers reported more

Table 6. Results of Poisson models explaining the number of publications and technologies produced, Nigeria and Ghana, 2010.

Variables	Publication						Technology									
	Nigeria			Ghana			Nigeria						Ghana			
	Poisson			Poisson			Logit			Poisson			Logit		Poisson	
	Coef. [a]	Std. Err. [b]		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	Coef.	Std. Err.	
Individual level																	
Capacity																	
Education	0.42	0.03	***	0.31	0.05	***	0.13	0.22		0.33	0.11	***	-0.56	0.19	0.20	0.07	***
Years post degree	0.00	0.08		0.24	0.08	***	0.14	0.55		-0.07	0.24		-0.14	0.42	0.27	0.12	**
Years post degree squared	0.01	0.01		-0.02	0.01	***	-0.01	0.06		0.00	0.03		0.03	0.04	-0.03	0.01	**
Years in current organization	0.06	0.03	**	0.10	0.02	***	-0.83	0.27	***	-0.52	0.12	***	-0.02	0.12	0.08	0.04	**
Female (dummy)	-0.32	0.05	***	0.22	0.10	**	-0.09	0.42		-0.37	0.22	*	-0.17	0.49	0.20	0.12	
Incentive																	
Time for research (%)	0.01	0.00	***	0.00	0.00		-0.01	0.01		0.01	0.00	***	-0.02	0.01	-0.01	0.00	***
Satisfaction with salary	-0.11	0.12		0.14	0.46		-0.40	0.33		0.30	0.28		0.19	0.39	0.22	0.25	
Individual score for OC	-0.39	0.16	*	-0.14	0.06	**	-0.22	0.41		-0.98	0.24	***	0.06	0.21	-0.13	0.05	**
Both capacity and incentive																	
Age	0.51	0.15	***	0.75	0.50		-1.33	1.31		0.09	0.58		-1.85	1.90	0.44	0.64	
Age squared	-0.10	0.02	***	-0.08	0.06		0.16	0.18		0.01	0.08		0.22	0.25	-0.05	0.08	
Organizational level																	
Capacity																	
Score for org. funding	0.35	0.13	***	-0.15	0.39		0.44	0.20	**	0.44	0.08	***	-0.08	0.42	-0.18	0.19	
Score for human resources	0.01	0.14		1.08	0.51	**	-0.48	0.20	**	0.00	0.11		-0.93	0.81	0.30	0.16	**
Score for ICT	-0.11	0.14		0.15	0.56		-0.40	0.24	*	-0.30	0.09	***	0.18	0.89	0.43	0.26	*
Score for physical resources	0.34	0.13	***	-0.14	0.39		0.42	0.21	**	0.42	0.09	***	-0.06	0.62	-0.15	0.19	
Score for org. linkages	-0.08	0.13		0.05	0.39		-0.35	0.23		-0.55	0.09	***	0.38	0.55	0.07	0.17	
Incentive																	
Score for M&E system	0.26	0.13	*	-0.31	0.27		0.74	0.25	***	0.35	0.12	***	-0.63	0.46	0.00	0.15	
Org. average for OC	-0.39	0.18	*	-0.13	0.05	**	-0.22	0.41		-0.99	0.25	***	0.05	0.21	-0.13	0.06	**
Control-type (dummy)				-0.13	0.06	**							0.09	0.10	-0.13	0.03	**
Both capacity and incentive																	
Research Institute (dummy)	1.17	0.20	***	0.28	0.40		-0.70	0.62		0.88	0.32	***	0.60	0.81	0.28	0.24	

Table 6. Contd.

Constant	**-1.20**	**0.55**	**	**0.93**	**2.69**		**7.61**	**2.87**	***	**-0.07**	**1.56**		**3.16**	**5.49**	**-0.09**	**1.83**
Random effect (Intercept)	**0.79**	**0.12**	***	**0.45**	**0.10**	***				**0.90**	**0.19**	***			**0.31**	**0.10**
N	**344**			**237**			**344**						**237**			
Log likelihood	**-1495.34**			**-573.73**			**-301.15**						**-404.62**			
Pearson Chi-squared	**230.12**			**289.57**			**349.01**						**236.03**			
P-value	**0.42**			**0.38**			**0.32**						**0.24**			
Pseudo R-squared	**0.66**			**0.63**			**0.54**						**0.58**			

[/a] Reported values are the coefficients and not the marginal effects. [/b] Figures are the coefficients and the ones in parentheses are the standard errors. *Significant at 0.10 level; **Significant at 0.05 level; ***Significant at 0.01 level. OC=organizational culture; org.=organizational; ICT=Information and communication technologies.

Table 7. Results of logit and poisson models explaining the extent of external collaboration and dissemination of publications produced, Nigeria and Ghana, 2010.

Variables	National research collaboration (dummy)				International research collaboration (dummy)				Number of dissemination events (count data)			
	Nigeria		Ghana		Nigeria		Ghana		Nigeria		Ghana	
	Coef. [/a]	Std. Err. [/b]	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Individual level												
Capacity												
Education	-0.38	0.16**	-0.43	0.30	0.36	0.18**	0.42	0.23*	0.22	0.04***	0.12	0.07*
Years post degree	-0.86	0.41**	-0.16	0.47	-0.20	0.47	0.40	0.42	-0.32	0.10***	0.30	0.13**
Years post degree squared	0.10	0.04**	-0.01	0.05	0.03	0.05	-0.06	0.04	0.04	0.01***	-0.02	0.01**
Years in current organization	0.24	0.17	-0.04	0.14	-0.03	0.17	0.21	0.12*	0.06	0.04	0.10	0.03***
Female (dummy)	0.23	0.32	0.08	0.55	0.01	0.35	0.43	0.50	-0.06	0.08	-0.37	0.15**
Incentive												
Time for research (%)	0.00	0.01	-0.03	0.02*	0.01	0.01	-0.02	0.02	-0.01	0.00***	0.02	0.00***
Satisfaction with salary	0.05	0.16	-1.15	0.95	-0.13	0.18	0.53	0.82	0.01	0.10	0.71	0.54
Individual score for OC	-0.11	0.34	0.32	0.23	-0.10	0.36	-0.34	0.23	-0.45	0.07***	-0.09	0.07
Both capacity and incentive												
Age	2.01	1.44	1.60	2.44	2.40	1.72	-1.70	2.06	0.25	0.19	1.58	0.70**
Age squared	-0.25	0.19	-0.11	0.32	-0.28	0.22	0.19	0.27	-0.04	0.03	-0.21	0.09**
Organizational level												
Capacity												
Score for org. funding	0.05	0.16	-1.17	0.92	-0.13	0.18	-0.45	0.72	-0.02	0.10	0.81	0.24***
Score for human resources	-0.14	0.15	-2.16	1.37	-0.04	0.17	0.13	1.13	0.12	0.10	0.10	0.31

Table 7. Contd.

Score for ICT	0.05	0.17	2.00	1.19*	0.29	0.19	1.50	1.09	-0.04	0.11	-0.31	0.30
Score for physical resources	0.04	0.16	-1.15	0.95	-0.12	0.18	-0.43	0.82	-0.01	0.10	0.91	0.24***
Score for org. linkages									-0.14	0.09	0.32	0.19*
Incentive												
Score for M&E system	-0.05	0.16	0.32	0.67	0.20	0.18	-0.67	0.58	-0.08	0.10	-0.10	0.15
Org. average score for OC	-0.12	0.34	0.31	0.23	-0.10	0.36	-0.33	0.23	-0.47	0.17***	-0.09	0.07
Control-type (dummy)			0.15	0.14			-0.02	0.14			0.04	0.03
Both Capacity and Incentive												
Research Institute (dummy)	-0.43	0.46	1.83	1.15	-0.12	0.46	0.58	0.96	0.95	0.21***	-1.98	0.30***
Constant	**-2.47**	**2.70**	**-2.01**	**7.27**	**-7.32**	**3.40****	**1.33**	**6.60**	**-0.04**	**0.54**	**-5.65**	**1.81*****
Random effect (Intercept)	**0.00**	**0.39**	**0.00**	**0.38**	**0.00**	**0.31**	**0.52**	**0.31**	**0.54**	**0.10**	**0.00**	**0.08**
N	***344***		***237***		***344***		***237***				***344***	***237***
Log Likelihood	***-152.58***		***-67.65***		***-139.42***		***-85.16***				***-1097.40***	***350.72***
Pseudo R-squared	***.34***		***.36***		***.38***		***.43***				***.55***	***.58***
% correctly predicted	***67%***		***75%***		***62%***		***71%***					
Pearson Chi-squared											***103.23***	***256.32***
P-value											***.43***	***.35***

[/a] Reported values are the coefficients; [/b] Figures are the coefficients and the ones in parentheses are the standard errors. *Significant at 0.10 level; **Significant at 0.05 level; ***Significant at 0.01 level. OC=organizational culture; org.=organizational, ICT=information and communication technologies.

publications in Ghana than male researchers; and it is the opposite in Nigeria. The results here are less conclusive than those reported in past studies.

In terms of individual incentives, time for research is positively related to the number of publications in Nigeria, as expected, but not in Ghana. Individual score for organizational climate is significant in explaining the number of publications in both countries. There is a quadratic relationship between age and number of publications in Nigeria, which is expected, but none in Ghana. Satisfaction with salary and compensation did not seem to be significant in explaining variations in the number of publication produced. Efforts were also made to use organization-level per-person salary costs (that is, salary cost as a ratio of full-time equivalent staff), and this indicator is also not significant.

In terms of organizational capacity, scores for funding and physical resources seem to be significant in Nigeria, while score for human resources adequacy seems to be significant in Ghana. In terms of organizational incentive, score for M&E system seems to be significant in Nigeria, and not in Ghana.

The score for organizational climate is significant for both Ghana and Nigeria. Organizations with control-type OC are more likely to have fewer publications than those with flexible-type OC.

The random-effect intercept, after controlling for organizational-level factors, remains significant, which means that the nature and other characteristics of the sample organizations are important factors in explaining individual productivity other than those used in the regression estimation.

Technology

In terms of individual capacity, similar to publications produced, the education level of researchers is significant in explaining variations

Table 8. Results of logit models explaining the extent of external collaboration and knowledge of adoption of technologies produced, Nigeria and Ghana, 2010.

Variables	International technology collaboration (dummy)				National technology collaboration (dummy)				Knowledge of adoption or evaluation (dummy)			
	Nigeria		Ghana		Nigeria		Ghana		Nigeria		Ghana	
	Coef. [a]	Std. Err. [b]	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Individual level												
Capacity												
Education	1.57	0.94*	0.36	0.28	0.10	0.32	0.07	0.25	-1.06	0.40	-0.22	0.40
Years post degree	4.00	3.11	0.78	0.55	-0.45	0.79	0.40	0.47	1.02	0.85	-0.18	0.81
Years post degree squared	-0.44	0.33	-0.03	0.05	0.04	0.09	-0.03	0.05	-0.12	0.09	0.02	0.09
Years in organization	0.76	1.10	0.17	0.15	0.39	0.42	0.00	0.14	0.85	0.46*	0.37	0.25
Female (dummy)	2.83	1.89	0.22	0.60	-0.11	0.59	0.59	0.56	0.00	0.70	-0.19	0.81
Incentive												
Time for research (%)	-0.02	0.03	0.04	0.02**	-0.01	0.01	0.01	0.02	0.00	0.02	0.02	0.03
Satisfaction with salary	0.09	0.45	0.51	1.02	0.27	0.32	0.87	1.29	0.03	0.41	2.97	2.75
Individual score for OC	-2.53	1.98	0.15	0.22	-0.93	0.66	0.17	0.25	-0.83	0.36**	-0.85	0.43*
Both Capacity and Incentive												
Age	-2.15	2.97	-0.71	2.35	-0.78	1.87	2.45	2.48	1.16	2.17	3.82	3.90
Age squared	0.27	0.42	0.02	0.31	0.08	0.25	-0.31	0.32	-0.06	0.30	-0.47	0.50
Organizational level												
Capacity												
Score for org. funding	0.33	0.72	1.94	0.73**	0.34	0.28	0.65	0.93	0.35	0.33	3.91	3.02
Score of human resources	-0.09	0.86	0.41	1.45	-0.25	0.33	-0.99	1.39	0.02	0.41	-6.97	104.75
Score for ICT	-0.41	0.81	-2.55	1.11**	-0.01	0.32	-2.57	1.20**	0.00	0.40	-12.86	109.86
Score for physical resources	0.32	0.74	1.84	0.83**	0.44	0.28	0.55	0.94	0.35	0.33	4.91	24.02
Score for org. linkages									-0.62	0.39	12.69	102.36
Incentive												
Score for M&E system	0.41	0.88	0.39	0.64	0.23	0.31	0.36	0.72	0.11	0.37	7.43	18.15
Org. average score for OC	-3.53	2.54	0.13	0.27	-0.92	0.66	0.15	0.25	-0.83	0.36**	-0.73	0.43*
Control-type (dummy)			-0.22	0.16			-0.08	0.17			-0.09	0.69
Both Capacity and Incentive												
Research Institute (dummy)	3.47	2.59	-0.19	1.02	-0.36	0.82	0.90	1.07	2.04	1.01**	10.09	107.67
Constant	**-20.00**	**12.53**	**6.02**	**7.45**	**0.87**	**4.71**	**-0.67**	**8.00**	**-7.00**	**5.49**	**-1.00**	**203.97**
Random effect (Intercept)	**2.16**	**1.60**	**0.18**	**0.96**	**0.00**	**2.32**	**0.57**	**0.39**	**0.41**	**1.26**	**0.00**	**0.32**
N	**344**		**237**		**344**		**237**		**344**		**237**	
Log Likelihood	**-29.74**		**-57.71**		**-50.78**		**-69.91**		**-42.65**		**-33.48**	
Pseudo R-squared	**0.30**		**0.28**		**0.31**		**0.30**		**0.32**		**0.29**	
% correctly predicted	**65%**		**62%**		**72%**		**60%**		**68%**		**70%**	

Note: [a] Reported values are the coefficients; [b] Figures are the coefficients and the ones in parentheses are the standard errors. *Significant at 0.10 level; **Significant at 0.05 level; ***Significant at 0.01 level. OC=organizational culture; org.=organizational; ICT=Information and communication technologies

in individual productivity in both Nigeria and Ghana. The number of years after highest educational attainment is significant in Ghana but not in Nigeria, and the direction of effect are opposite between these two countries. The

number of years in the organization is significant for both countries but of different direction. More number of years in the current organization is negatively associated with the number of technologies produced by individual researchers in Nigeria and positively associated with technologies produced by individual researchers in Ghana. In Nigeria, female staff has reported fewer technologies produced than male researchers; while in Ghana, it is the opposite, that is, female researchers produced more than their male counterparts, although it is not statistically significant.

In terms of individual incentive, more time allocated for research is positively associated with technology produced by individual researchers in Nigeria and negatively related to technologies produced by individual researchers in Ghana. Similar to publications above, individual score for organizational climate is significant in explaining the number of technologies in both countries. Satisfaction with salary and compensation did not seem to be significant in explaining variations in the number of technologies produced. Efforts were also made to use organization-level per-person salary costs (that is, salary cost as a ratio of full-time equivalent staff), and this indicator is also not significant. There is no relationship between age and number of technologies produced per staff for both countries.

In terms of organizational capacity, scores for funding, ICT, physical resources seem to be significant in Nigeria, while score for human resources adequacy and ICT system seems to be significant in Ghana. In terms of organizational incentive, score for M&E system seems to be significant in Nigeria, and not in Ghana. The score for organizational climate is significant for both Ghana and Nigeria. Organizations with control-type OC are more likely to have fewer technologies generated per staff than those with flexible-type OC.

The random-effect intercept, after controlling for organizational-level factors, remains significant, which means that the nature and other characteristics of the sample organizations are important factors in explaining individual productivity other than those used in the regression estimation.

Collaboration in publications

Individual capacity factors are associated with international research collaboration in Ghana and Nigeria and national research collaboration in Nigeria (Table 7). Education level is consistently significant in explaining the international research collaboration and number of dissemination events by individual researchers in Ghana and Nigeria, which is expected. However, a surprising result is on the direction of significance in explaining national research collaboration in both countries, that is, the higher the education level, the less likely individual researchers collaborate with other researchers in their publications. There seems to be a substitution of international collaboration from national collaboration as one achieves higher education background in both countries.

Except of a slight significance of index for communication system (explaining national research collaboration), there seems to be no organizational factors that are statistically significant in explaining both national and international research collaboration. It seems that international and national collaboration of researchers in their publications are explained mainly by differences in individual characteristics, especially education level and years of experience, and not on the nature or characteristics of organizations they are in.

Collaboration in technology development

Only education is significant in explaining variations in technology development collaboration in Nigeria (Table 8). Higher education level is positively associated with presence of international collaboration in technology development. No variable (both individual and organizational level factors) is statistically significant in explaining national collaboration in technology development in Nigeria in our models. For Ghana, there are no individual factors that are statistically significant in explaining both national and international collaboration in technology development, except for time allocated for research.

More time for research is positively associated with international collaboration in technology development. In terms of organizational factors, the score for physical resources is positively associated related to national and international collaboration. However, score for communication system is negatively associated with both national and international collaboration.

Dissemination of publications

Both individual and organizational factors are significant in explaining the number of dissemination events to communicate the findings of research (Table 7). Education level is consistently significant in explaining the number of dissemination events of sample agricultural researchers in Nigeria and Ghana, as expected. Higher education level is positively associated with more dissemination events. The number of years of experience after highest education attainment is also significant, although the effect is opposite for Nigeria and Ghana. More years in the current organization is positively associated with number of dissemination events in Ghana. Female researchers have less dissemination events for both Nigerian and Ghana (although it is not

significant for Nigeria). In terms of individual incentive, time for research is significant, but with opposite direction in Nigeria and Ghana. More time for research is associated with more dissemination events in Ghana, while time for research seems to be crowding out for time spent on dissemination of publications in Nigeria. Score for organizational climate is significant in Nigeria and not for Ghana. There is a quadratic relationship between age and dissemination of publications in Ghana, which is expected, but none in Nigeria.

In terms of organizational capacity, the score for physical and financial resources and score for organizational linkages are positively significant in Ghana, but not in Nigeria. In terms of organizational incentives, score for organizational climate is significant in Nigeria and not for Ghana. The type of OC is not significant in explaining dissemination of publications.

Knowledge of evaluation and adoption

More years in the current organization is positively associated with individual researcher's greater reported knowledge and awareness of adoption of technology produced in Nigeria, but no significance in Ghana (Table 8). Individual researcher's perception of organizational climate is significant in explaining knowledge on adoption or evaluation of technologies produced. More conducive work environment reported is associated with more knowledge on adoption and evaluation of technologies produced for both Nigeria and Ghana.

DISCUSSION

There is huge variability in the research outputs, productivity, organizational linkages, and extent of dissemination and knowledge of adoption of technologies produced among individual researchers and organizations involved in agricultural research in Nigeria and Ghana. Both individual and organizational characteristics and both capacity and incentive factors are significant in explaining variations in publications and technologies produced. Education level is strongly and positively significant in explaining variations in the number of publications and technologies produced external research collaboration, and the number of dissemination events for these publications. This implies that while interventions are needed to improve education level and skills development of staff, interventions to improve the workings of organizations will also be needed.

In terms of individual capacity, it is consistent that education is a highly significant factor. Length of stay in the organizations (proxy of experience and familiarity in the organization) is also consistently significant. Gender is also significant, but of different signs between Nigeria and Ghana. Female researchers are less likely to have more number of publications and more technologies produced than male researchers in Nigeria but it is the opposite in Ghana. Female researchers are more likely to have more publications and technologies produced but they are likely to have less dissemination events than their male counterparts in Ghana. This gendered pattern will need to be further investigated.

The pressing organizational constraints may be different from organization to organization and from country to country. For Ghana, score for human resources availability seem to be a significant factor in the number of publications and technology produced. In terms of external collaboration, other organizational factors including indices for communication system, linkages, physical resources, and the type of organizational culture become significant for Ghana. In Nigeria, scores for physical and financial resources and M&E system are statistically significant across different models. These imply the need for differentiated priorities and strategies needed in the reform processes in these countries.

For Nigeria, results suggest the need to strengthen and invest in physical resources and facilities upgrading and implementation of M&E systems if the Nigerian government aims to increase the research productivity of its agricultural research system. In 2010, only 30 organizations have M&E plans and a majority does not have strategic plan and intellectual property rights (IPR) policy. In the context of Nigeria, in terms of prioritization, human resources development seem to be the least of the problems compared to the serious deficiencies in laboratory, research facilities, and infrastructure and in poor implementation of management systems and M&E. Measures of availability and adequacy of physical resources and M&E and management systems seem to be more consistently significant than measures of availability of human resources in Nigerian case. Investing in physical resources and better enforcement organizational management systems seem to be the more important factors that would increase the likelihood of increasing research productivity.

For Ghana, the Council for Scientific and Industrial Research (CSIR) has to improve and invest on its human resources and communication and information systems, especially in its decentralized stations. It has to work on increasing research productivity (both technology and publication) and has to work more on increasing the level and quality of linkages and research collaboration. CSIR has to find a way to retain existing staff at the same time able to hire young staff, which will involve lifting the recruitment squeeze. There is also a need to look at better incentive system and higher compensation, especially in research institutes wherein staff turnover is a major problem and staff move to higher education

institutes due to better compensation and opportunities for staff development. All these actions require substantial investment needed from government and partners. While Ghana is almost to reach the target of 6 percent budget allocation to agriculture, Ghana's invest-ment is very low in relation to the size and importance of its agricultural sector (less than 2% compared to about 5% in Nigeria and 8 to 10% in agriculture-based Asian countries).

For both countries, it seems that organizational culture type and organizational climate directly research productivity. Attention must be paid to improve organizational climate in the R&D system. The gender of the organization head and of the researcher, are significant in most models. Further study is needed to understand why female researchers and researchers in organizations with female heads have lower indicators of organizational performance and individual research output. It might be that the gender effects in variations in productivity are due to gender differentials in access to opportunities and resources for research, collaboration, or dissemination.

Conclusions

Most studies on individual research productivity focus on individual characteristics, and this paper is among the first set of papers that models systematic variation in individual research productivity across organizations, and explicitly differentiating between capacity and incentive factors as well as organizational and institutional factors. Our exploratory study offers four concluding points and implications as well as several hypotheses that need further investigation. First, results of this study show that organizational factors matter in explaining variations in individual research productivity (measures in terms of quantity and quality of publications and technologies produced). Results of this study reinforces that improving organizational effectiveness can contribute to increased productivity of individual researchers. There are differences in the statistical significance and direction of correlation of various organizational-level factors between Nigeria and Ghana. This signifies local context matters and that various interventions need to be tailored to the specific context and constraints facing organizations and countries. In Ghana, quantity and quality of human resources seem to be the more pressing constraint; while in Nigeria, physical resources, and organizational M&E systems seem to be the more pressing constraints.

Second, organizational climate (enabling or disabling work environment) appears to be important in affecting research performance for both countries. Improving staff morale or simply making their staff satisfied and happy should be a major step to be followed for productivity and outreach to be improved. Improving on M&E system also reinforces greater incentive to produce more and better outreach, especially in the case of Nigeria. While improving capacity is important (through training and education of staff, or improving human, financial and physical resource), but improving the formal system of M&E and informal climate of the organization also matters in improving productivity and research outreach.

Third, organizational culture, reflecting the degree of control or flexibility, and inward and outward orientation, focus, and leadership type in the organization, is significant in explaining publications and technologies produced in Ghana. Organizations with flexible-dominated and group culture type have reported more publications and technologies generated than those in organizations with more control-dominated and hierarchical culture type. Unfortunately, we were not able to include this section of the questionnaire in Nigeria, and it would be great to know if this also applies there and in other countries.

Fourth, salary and benefit levels were consistently mentioned by researchers and heads of organizations, especially in Ghana, to be important motivating factor for increasing productivity but variations in the perceived competitiveness of salaries, adequacy of salaries relative to living expenses, and salary costs per FTE researcher did not appear to be statistically correlated with variations in any of the performance indicators. The majority of researchers suggested improvements in basic research facilities emphasized in both countries and skills development or capacity strengthening as emphasized in Ghana, which contrasts the much heavier emphasis on low salaries highlighted as the binding constraint in other studies, such as Byerlee (2004). Increasing capital investments and building physical resources seem to be important factors in both Nigeria and Ghana; and skills development in Ghana. But, further research is needed to investigate optimal salary levels, in recommending priority investments for increasing their productivity and output.

The paper should be taken as a pilot case, requiring further refinements to measurements and definitions, especially in the event that they are scaled out to other countries. As a future research agenda, better methods of collecting information as well as better indicators of adoption and impact of publications and technologies can be explored. A future line of inquiry will be to build up indicators of individual productivity of scientists and explore the relationship between individual and organizational productivity. It will also be useful to investigate further why female researchers appear to be more productive in Ghana and less productive in Nigeria than male researchers. The gender of the organization head is also statistically significant in explaining the presence of organizational management practices and organizational culture type across organizations. It might be that the gender effects in variations of productivity are

due to gender differentials in access to opportunities and resources for research, collaboration, or dissemination. Lastly, cross-sectoral or cross-national comparison can be explored further beyond and Nigeria to determine whether institutional or national context matter in explaining scientists' productivity.

Conflicts of Interest

The author has not declared any conflict of interest.

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Economic analysis of profitability and competitiveness of sugarcane enterprise in Nigeria

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In Nigeria, cultivation of Industrial Sugarcane has suffered a serious setback due to poor performance of government established and owned sugar companies. Arising from over-dependence on sugar importation, development in the Nigerian sugar industry has been very slow for the past three decades while the domestic supply of sugar had lagged behind the demand for the product, inspite of the country's comparative advantages for sugarcane production. This study is therefore necessary to examine profitability and competitiveness of sugarcane enterprises for attracting private investment and employment generation in the country. The study employed financial and economic indicators and the value chain approach in analyzing primary data collected in a sample survey of various actors across the sugarcane value chain. Results of the study revealed that every stage of the commodity chain is profitable. Domestic Resource Cost (DRC) Indices ranged from 1.8 for medium scale and 2.3for small scale operators. Thus sugarcane production is not internationally competitive. To develop the industry, investment in infrastructure and new innovative processing technology is required for the modernization and the expansion of local processing industries.

Key words: Agro-processing, investment, employment, income.

INTRODUCTION

Greater integration of rural economies into the world economy has intensified the need for Nigerian agriculture to change and be globally competitive. This imperative necessitates policies favouring greater competition, support for small and medium scale enterprises broadly, better resource allocation and stable production of raw materials. A stable production of raw materials provides a competitive and stable supply chain from which other competitive agro-processing industries can emerge. For decades, however, this has been problematic due to recurring failure of government programmes of agrarian reform and the resulting marginalisation of the rural economies. Nigeria was once a leading agricultural producer. In the 1960s, Nigeria produced over 60, 30, 20 and 15% of global exports in palm oil, groundnut, groundnut oil and cocoa, respectively. By the 2000s, Nigeria had lost her dominant position in exports of these key crops and the share of exports of each of these crops

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Table 1. Trend in consumption, production and importation of sugar in Nigeria, 1999-2012.

Year	Consumption		Production		Importation			
	Quantity in tonnes	Growth in %	Quantity in tonnes	Growth (%)	Quantity in tonnes	Growth in %	Import Cost in US Dollar ($)	Growth in cost of importation (%)
1999	781,782		10,000		771,782		185,227,680	
2000	771,890	-1.27	36,000	260.00	735,890	-4.65	198,690,300	7.27
2001	930,201	20.51	10,000	-72.22	920,201	25.05	239,252,260	20.41
2002	1,009,165	8.49	-		1,009,165	9.67	262,282,900	9.63
2003	988,441	-2.05	-		988,441	-2.05	256,994,660	-2.02
2004	865,000	-12.49	-		865,000	-12.49	229,225,000	-10.81
2005	1,301,494	50.46	-		1,301,494	50.46	281,416,777	22.77
2006	1,176,698	-9.59	50,000		1,126,698	-13.43	197,172,150	-29.94
2007	1,258,996	6.99	55,000	10.00	1,203,996	6.86	313,038,960	58.76
2008	1,396,668	10.94	38,000	-30.91	1,358,668	12.85	327,438,988	4.60
2009	1,220,080	-12.64	39,000	2.63	1,220,041	-10.20	395,293,284	20.72
2010	985,675	-19.21	30,000	-23.08	955,675	-21.67	482,615,875	22.09
2011	1,139,410	15.60	35,000	16.67	1,104,410	15.56	657,123,950	36.16
2012	1,108,980	-2.67	10,843	-69.02	1,098,137	-0.57	517,222,527	-21.29
Average	1,066,749	4.08	31,384	-23.70	1,047,114	4.26	324,499,665	10.64

Source: National Sugar Development Council, Abuja.

now reduced to 5% or less (CBN, 2011, 2015). Today, Nigeria is a net importer of agricultural produce, with total food import bill of USD4.2 billion annually out of which sugar, a final product of sugarcane, constitutes average amount of USD324.5 million annually for the period between 1999 and 2012 (Table 1).

Among 92 countries that belong to the international sugar organization, Nigeria is the only one that belongs to the category of sugar importers and it ranked fourth in 2009. Evidence showed that when compared to some selected West African Sugar producing countries, Nigeria is the least food secured in terms of sugar (National Sugar Development Council, 2012). Arising from the overdependence on sugar importation, cultivation of industrial sugarcane has suffered a serious setback due to poor performance of government established and owned sugar companies in Nigeria. Development in the Nigerian sugar industry has been very slow for the past three decades while the domestic supply of sugar had lagged behind the demand for the product, inspite of the country's comparative advantages for sugarcane production. The desired productivity improvements and competitiveness in Nigerian Sugracane enterprises have been difficult to achieve over the years due to weaknesses in the commodity marketing system and the lack of attention to develop the commodity chain, produce value added products and enhance market access. The food and agricultural markets are extremely fragmented along sub-national levels, resulting in segmented markets of sub-optimal size which does not ensure profitability of sizeable private investment in the different stages of the sugarcane value chain. The resulting supply-demand gaps in sugar which is one of the final products of sugarcane is increasingly being filled by imports; thus further dampening the prospects for transformation of sugarcane enterprises, revenue generation and poverty reduction.

In the recent time, sugarcane output has demonstrated unsteadiness and irregularity in its trend as indicated by Table 2. Growth in output of sugarcane declined from 52.58% in 2007 to negative 3.29% in 2011. Impressive trend in the output growth that was recorded for the years between 1999 and 2007 has not been recovered. The depressing growth in output of the commodity was strongly correlated with the trends in area planted and the yield realized. Growth in area planted to cassava had declined substantially from 34.04% in 2007 to negative 1.51% in 2011. Similarly, the yield of the crop declined consistently between 2007 and 2011 (faostat, 2015). Sugar industries in Nigeria rely more on cultivars brought in from overseas rather than those developed in Nigerian Research Institutes, for reason usually not beyond inadequate information about the performance of the cultivars that were bred in the country. The country's sugar industry only supplies about 3% of the nation's requirement as shown by Table 3. Most of the African neighbours produced substantial proportions of their sugar requirements while Nigeria can only meet insignificant proportion of domestic demand though domestic production. This had led to rising expenditure on imports of sugar.

Admitedly, in the context of the current global decline in oil price, it is now imperative for the county to aspire to attain and maintain high productivity and product quality for her agriculture to compete in the world market place and maintain a high standard of living for her citizens.

Table 2. Trend in output, area planted and yield of sugarcane in Nigeria, 1999-2011.

Year	Output		Area Planted		Yield	
	Actual in tonnes	Growth in %	Actual in hectare	Growth in %	Actual tonnes/ha	Growth in %
1999	682,000		24,000		28.42	
2000	695,000	1.91	24000	0.00	28.96	1.91
2001	705,000	1.44	23000	-4.17	30.65	5.85
2002	750,000	6.38	40000	73.91	18.75	-38.83
2003	798,000	6.40	42000	5.00	19.00	1.33
2004	854,000	7.02	43000	2.38	19.86	4.53
2005	914,000	7.03	44000	2.33	20.77	4.59
2006	987,000	7.99	47000	6.82	21.00	1.09
2007	1,506,000	52.58	63000	34.04	23.90	13.83
2008	1,412,070	-6.24	71890	14.11	19.64	-17.83
2009	1,401,680	-0.74	73060	1.63	19.19	-2.33
2010	1,478,180	5.46	77550	6.15	19.06	-0.65
2011	1,429,570	-3.29	76380	-1.51	18.72	-1.81
Average	1,047,115	7.16	49,914	12	22.15	-2.36

Source: FAOSTAT, 2014, National Bureau of Statistics and Central Bank of Nigeria Annual Report, 2015. Abuja, Nigeria.

Table 3. Self-sufficiency in sugar among some selected West African Countries in 2009.

Country	Total sugar demand in metric tonne	Totalsugar production in metric tonne	Production as percentage of demand (%)
Nigeria	1,994,175	30,000	3
Benin Republic	39,062	10,000	25.6
Burkina Faso	85,106	40,000	47
Cote d' Ivoire	226,565	145,000	64
Senegal	188,000	99,000	50
Mali	103,030	34,000	33

Source: National Sugar Development Council, 2012.

The country must therefore get her agricultural policies and strategies right in order to move her economy into high-value sectors that will generate jobs for the future. The fall in the prices of oil and rising unemployment in the country has prompted the need to diversify the economy in general and the agricultural sector in particular. Again, the recession currently being experienced in the the economy indicates the advisability to reposition Nigerian agriculture in an increasingly globalized world. This is to ensure that supply and demand in the sector can take place in such a way as to provide optimum benefits to the economic agents involved, as opposed to the current situation in which Nigeria is serving as suppliers of raw materials to foreign consumers who have considerable influence over the prices of such commodities through a plethora of institutional arrangements. If the agricultural commodity value chains are well developed in Nigeria, substantial part of the rising food demand can be satisfied with domestic production rather than with imports and this could generate considerable gains in income for smallholder producers. In this regard, the paper aimed at providing answers to the following questions. How can productivity and marketing be improved in sugarcane enterprises so as to encourage private investment in the sector? How can competiveness be improved in the sector? How can the nation ensure a considerable change in the market value of what local producers have to sell? What are the constraints to competitiveness and profitability of the enterprise at the different nodes of the sugarcane value chain? How can the constraints be removed? These are the major challenges the paper attempted to address.

THEORETICAL FRAMEWORK AND REVIEW OF LITERATURE

Concept of competitiveness is difficult to deal with. This difficulty can be tackled by adopting a definition in line with the focus of the paper. In Harvard University,

competitiveness is defined as the ability of a nation to produce, distribute goods and services that compete in the international economy with goods and services produced in other countries that brings about a rising standard of living. This definition assumes a national goal of improving the well-being of the population. This paper adopts the definition of competitiveness as the sustained ability to profitably gain and maintain market share in domestic and export markets. Although the meaning is not straightforward at the industry level, competitiveness implies the ability of a group of like firms to compete with another group in another sector or the same sector in another country (Gourichon, 2013; Coffin et al., 1993). An important advantage of this definition is that it provides some measurable dimensions. For the purpose of this paper, the same definition that "ability to sustain market share and profitability" will be adopted, particularly at the microeconomic level analysis. Thus, this paper, at the microeconomic level, considered the capacity of the economic actors along the value chain of sugarcane, to compete, grow and be profitable. Any firm will be expected to meet these requirements if it is to remain in business, and the more competitive a firm relative to its rivals, the greater will be its ability to gain market share.

Conversely, uncompetitive firms will find their market share decline, and they ultimately remain uncompetitive unless furnished with some artificial support or protection and will go out of business. At the macro level, the term competitiveness has been criticised and considered meaningless by Krugman (1994), who states that it could be misleading and incorrect to make an analogy between a nation and a firm; for example, whereas an unsuccessful firm will ultimately go out of business, there is no equivalent "bottom-line" for a nation. He states further that whereas firms can be seen to compete for market share and one firm's success will be at the expense of another, the success of one country or region creates rather than destroys opportunities for others and trade between nations is considered a 'zero-sum game'. This view is supported by the general consensus which seems to recognise that improvements in one nation's economic performance need not be at the expense of another. It is not necessarily in a win or lose situation, and productivity is one of the central concerns of competitiveness. For instance, "an economy is competitive if its population can enjoy high and rising standards of living and high employment on a sustainable basis. More precisely, the level of economic activity should not cause an unsustainable external balance of the economy nor should it compromise the welfare of future generations". Some of the underlying factors that will influence competitiveness are technology, attributes of purchased inputs, product differentiation, production economies, and external factors (Schnepf et al., 2003).

In the light of the foregoing, competitiveness is an indicator of the ability to supply goods and services in the location and form and at the time they are sought by buyers, at prices that are as good as or better than those of other potential suppliers, while earning at least the opportunity cost of returns on resources employed. Two types of competition are included in this definition. First, the competition on domestic and international product markets and thus the ability to gain and maintain market shares, and second, the competition in factors markets, where those factors employed in producing the goods have to earn at least the opportunity costs (Klaus and Monika, 1997). Although pointing to different aspects, both types are indicative of the fact that competitiveness is a relative measure. One always has to make the comparison with a base value. In the case of a market share, it is with regard to market size. If one assesses competitiveness in factor markets, the relation is to the value a factor would have in another production process. To maintain a standard of living, higher productivity and product quality have become essential (Smit, 2010). The ability of a nation to produce a high and rising standard of living for its citizens depends on the productivity with which a nation's labour and capital are employed. Productivity is the value of the output produced by a unit of labour or capital. Productivity depends on both the quality and features of products which determine the prices that they can command and the efficiency with which they are produced. Productivity is the prime determinant of a nation's long-run standard of living. It is the root cause of national per capita income (Porter, 1990).

METHODOLOGY

Nature and sources of data

Both primary and secondary data were used. Primary data derived mainly from producers (farmers), processors, marketers including wholesalers and retailers through a survey conducted in 2014. This was done with the use of well-structured questionnaires. Data collected from relevant actors at every level in the chain included size of operations, farm size, costs of equipment for production, storage and processing, fixed assets, revenues, labour (family and hired), input and output prices, wage rate, and interest rate. Secondary data were collected from government publications and organizations such as National Sugar Development Council of Nigeria (NSDCN), Agricultural Development Programmes (ADPs), National Bureau of Statistics office in Abuja, Central Bank of Nigeria, National Agricultural Extension and Research Liaison Services (NAERLS), and Federal Ministry of Agriculture and Rural Development. FAOSTAT and other internet sources provided information on consumption, domestic production and importation of sugar, output figures, yield of sugarcane and land area cultivated to the crop.

Sampling procedure and data collection

The entry point for the study is the farm. In selecting the farm, emphasis was placed on the agro-ecological zones with the greatest comparative advantage in the production of sugarcane. In effect therefore, selected geo-political and agro-ecological zones of the country in which sugarcane is predominantly cultivated and

where sugar is marketed were covered. Selected zones for producers, processors, and wholesalers are north west, northeast, north central and Federal Capital Territory, Abuja. Selected state in the north west is Kano, northeast is Adamawa while the selected state in the north-central is Niger. For urban retailers, Lagos state in the Southwestern zone was also selected. From the farm, the actors responsible for pre and post-harvest activities up to the final destination in sugarcane value chain were traced. In Numan, Adamawa State, 100 farmers cultivating sugarcane were randomly selected from the list of farmers participating in the out-grower's scheme of the Savannah Sugar Company. Relevant data were collected from the selected farmers using structured questionnaire. Similarly Savannah Sugar Company in Numan, Adamawa Sate was visited and relevant data were collected from the company.

Method of analysis

An important technique of measuring competitiveness which was adopted in the study is accounting method which entails use of indicators such as production costs and gross margins. It is used to compare farms to indicate which enterprise has a competitive advantage. Gross margins are obtained by substracting costs of variable inputs from gross revenue. Since these calculations can be carried out only for a single commodity, such analyses are done at the product level. To allow for easier comparison, it is common to normalize gross margins, for example, with the value of sales or labour costs. This indicator can provide rather detailed insights into the reasons why enterprises across regions are not competitive in a particular good. This is due to the fact that the index is based on a rather detailed breakdown of the various cost items of production and, hence, offers a comparison at this level.

Moreover, descriptive and inferential statistics such as means and percentages were used in the analysis of data. Profitability of the chain was measured by the relative earnings of each agent. Economic analysis provides insights into the key economic indicators such as the gross revenue of the various actors in the chain, the gross margin at each level and the profitability (net profit) at each level. The economic analysis is important to developing a growth strategy for upgrading the chain. For the analysis household consumption, family labour, and paid out cost were valued. The analysis involved estimations of the following indicators:

i. Gross Revenue = Value of Output = Quantity of output multiplied by unit price represented by $VQ_i = PiQ_i$
ii. TVC = Total variable costs = Costs of all variable inputs used.
iii. Total Costs = The addition of all variable costs and fixed costs incurred by each actor in the chain.
iv. Gross margin is gross profit which expresses the economic gain or loss to the agent once all current production cost are met. It is estimated by Gross Revenue minus Total Variable Cost.
v. Net Profit: Gross Revenue minus Total Cost. The net profit measures the increase in wealth of the individual agent.
vi. Gross rate of return = Gross Margin/ Total variable costs.
vii. Net Rate of Return = Net Profit/Total Production Costs.

Another important indicator, the coefficient of domestic resource cost (DRC), which is derived from the microeconomic profit function on the basis of economic prices, and which is most often used in the measurement of competitiveness (Bamou, 2002), was also adopted in this study. The DRC is a measure of a product's capacity to penetrate the international market. In other words, it is to measure whether the local production can use the resources better than the rest of the world. If Nigeria is to produce a commodity for the world market, the concern is that the realizable world price in Nigerian Naira covers the costs of exports and an adequate profit margin. The exporter's attraction to deal in the export commodity is a function of the size of this margin. The bigger the margin the more attractive is the commodity. The economic basis of analyzing export competitiveness of Nigerian sugarcane on the world market was therefore computed using the Domestic Resources Cost (DRC).

DRC as a measure of competitiveness

The DRC is the domestic resources cost for a unit of net foreign exchange. One of the various methods that have been used to measure DRC assumes that the production of a commodity i is based on a production technique, t. Thus, supposing that two types of inputs, namely, imported inputs or tradable, and local resources or non-tradable were used in the production of the commodity. The imported inputs known as (m) are subject to taxes or subventions, while the local ones are not subject to either taxes or subventions. The producer profit function of the commodity (i) for the production technique t can be expressed as followed:

$$NEP\ t, l = Pi\ Qt,l - \sum Pm.a^{t}m,i - \sum_{l} pl\ .bl^{t},i \quad (1)$$

$NEP_{t,i}$ = net economic profit for the production techniques t; $Q_{t,l}$ = the quantity of output (i) produced by technique t; am,i^{t} = the quantity of imported input (m) used in the production output (i) for the technique (t); b_l, i^{t} = the quantity of local resources (l) used in the production of output (i) for the techniques (t). Pi = shadow price of output (i); Pm = shadow price of imported input m; P_l = financial cost of local resources (l)

Where NEP is positive, such production technique is economically profitable. However, where NEP described above is positive, the criterion developed to measure the efficiency of resource allocation can be obtained by simple mathematical manipulation of the NEP (Bamou, 2002). Therefore:

$$BEN_{t,i}\ \ f\ 0\ \text{if}\ P_i.Q_{t,i} - \sum_{m} pm.a^{t}_{m,i}\, f \sum_{l} pl - b^{t}_{l,i} \quad (2)$$

Given the above expression, the following quotient can be used to eliminate the effects of scale.

$$\frac{\sum_{l} \mathrm{p\,l.b}^{t}_{l,i}}{\mathrm{P_i}Q_{t,i} - \sum_{m} P_m.a^{t}_{m,i}} < 1 \quad (3)$$

The denominators in these quotient represent the value added generated by imported inputs while the numerator represents the local costs in accounting prices of the inputs used in the production of the commodity i. This quotient can thus be interpreted as the domestic resource cost for a unit of foreign currency earned from exports. In order to give the quotient a shadow value in a single currency (local currency), an exchange rate is introduced. The harmonized ratio, known as a coefficient of the DRC, is thus expressed as:

$$DRC_i = \frac{\sum_{l} \mathrm{p\,l.b}_{l,i}}{(\mathrm{P_i}Q_{t,i} - \sum_{m} P_m.a_{m,i}).\ e^{r}/e^{0}} \quad (4)$$

Where e^{r} and e^{o} are shadow exchange rate and official exchange rate respectively.

Based on the law of comparative advantage, the DRC index is

Table 4. Structure of financial costs of sugarcane enterprise in Nigeria per metric tonne.

Farm gate product		Assembled raw material		Processed raw material		Traded commodity	
Cost items	**Percentage of total cost**	**Cost items**	**Percentage of total cost**	**Cost items**	**Percentage of total cost**	**Cost Items**	**Percentage of total**
Fertilizer	22.58	Purchased products	59.35	Purchased products	25.34	Purchased products	95.69
Labour	20.92	Labour	24.11	Energy	20.58	Labour	3.9
Rent	17.45	Energy and Machine maintenance	5.73	Storage, Machine repairs and maintenance	26.85	Marketing and Transportation	0.4
Irrigation water	14.18	Rent	5.03	Packages and Consumables	8.95	Total	100
Interest on Loans	13.08	Marketing and Transportation	3.87	Hired Labour	18.28		
Herbicides	5.08	Others	1.91	Total	100		
Seed	2.87	Total	100				
Others	3.84						
Total	100						

Source: Author's Computation, Underlying data derived from Field Survey,2014.

therefore expressed thus:

1. If the DRC index is lower than 1, it means fewer resources are needed to generate a unit of foreign currency. In essence, the world market price is greater than the resource cost used in production. Thus, compared to the rest of the world, the country uses its resources more effectively and therefore has a comparative advantage in the production activity.
2. If the DRC is greater than 1, it implies that more local resources are required to produce a unit of foreign currency so, the country has no comparative advantage in the production activity.

EMPIRICAL RESULTS AND DISCUSSION

Structure of financial costs of sugarcane enterprises

Both the magnitude and structure of financial costs are important in commodity chain analysis. The magnitude of cost will affect the performance of the commodity value chain while the structure will provide the opportunity to identify specific cost items that can be targeted by actors in a bid to improve the performance of the chain. As expected, the type and composition of financial costs of sugarcane commodity chain vary from one stage to another. The structures of financial costs of the sugarcane enterprise per metric tonne across the various stages of the commodity chain in Nigeria are summarised in Table 4 while Figures 1 to 4 indicated the graphical illustrations of the cost structures at the farm gate, assembly, processing, and logistic trading stages respectively. As shown by Table 4 and Figure 1, sugarcane production cost at the fam gate stage is distributed over five major factors that are important. These are purchased inputs (31%) in which fertilizer dominates with 23% share of the total cost, hired labour accounts for 21%, renting of equipment accounts for 17%, while interest paid accounts for 13%. In Table 4 and Figure 2, five major factors are important in the financial costs of sugarcane enterprise at assembly stage. These are products purchased (59%), labour (24%), energy and machine maintenance (6%), rent (5%), marketing and transportation (4%).

At processing stage, five variables are important in the cost of processing sugarcane. The combination of storage, machine repairs and maintenance cost dominates the cost structure, with 27% share of the total cost. About 25% of the total cost goes to product purchased. Product purchased ranked second in the order of importance among the five variables that are substantial in the cost structure. Following this is cost of energy which constitutes about 21% of the total cost. The fourth variable that contributes substantially to total cost at the processing stage is hired labour. About 18% of the total cost goes to hired labour. A combination of packages and consumables constitutes the fifth factor that is important in determining the total cost at the processing stage. About 9% of the total cost goes to packages and consumables (Figure 3).

At the logistics stage (domestic distribution), the relevant cost items in order of importance are product purchased (56% of total cost), marketing and transportation (30%), labour (14%) (Figure 4). Overall, across all stages, the analysis of cost

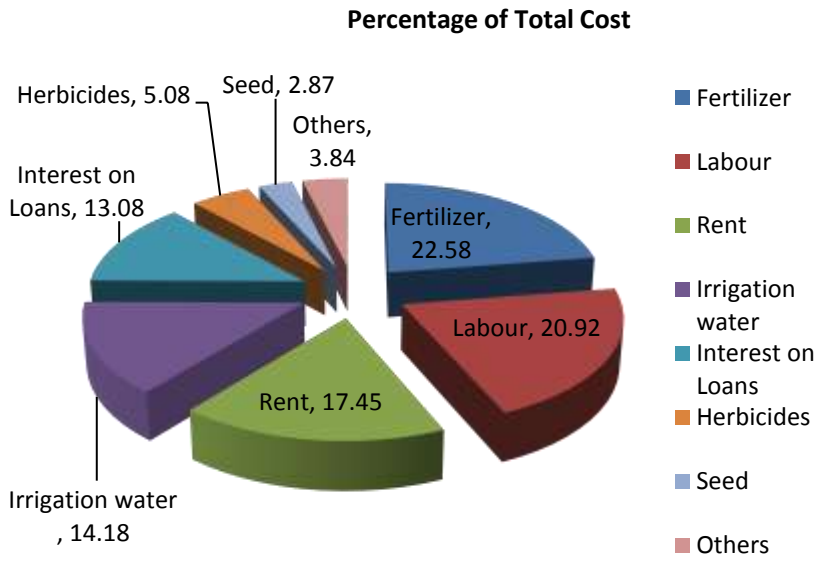

Figure 1. Build-up of finanacial cost at farm gate. Source: Author's computation.

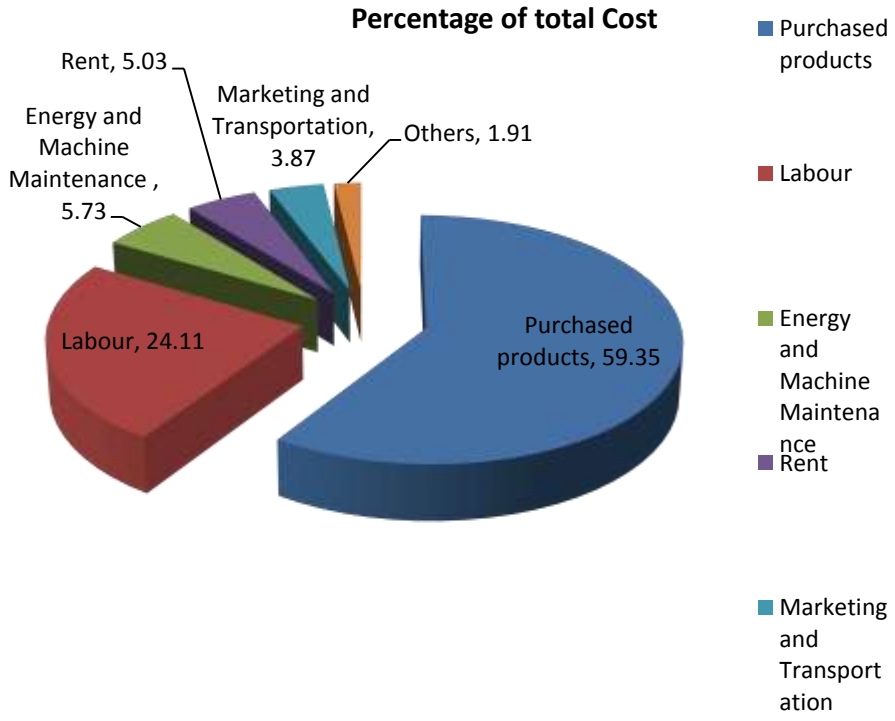

Figure 2. Build-up of financial cost at assembly stage. Source: Author's computation.

structure clearly indicates dependency on hired human labour which is favourable for employment generation across the various stages of the commodity chain. Other factors that frequently occur as crucial variable affecting cost of operation include renting of infrastructures such as warehouse, shops, equipment and machines, as well as fuel, purchased inputs mainly herbicides, pesticides and fertilizer. Cost of fuel and transportation cost of moving goods from point of sale to delivery point and cost of quality inputs such as fertilizer, improved seeds and pesticides have affected the cost of operation particularly at the farm gate level.

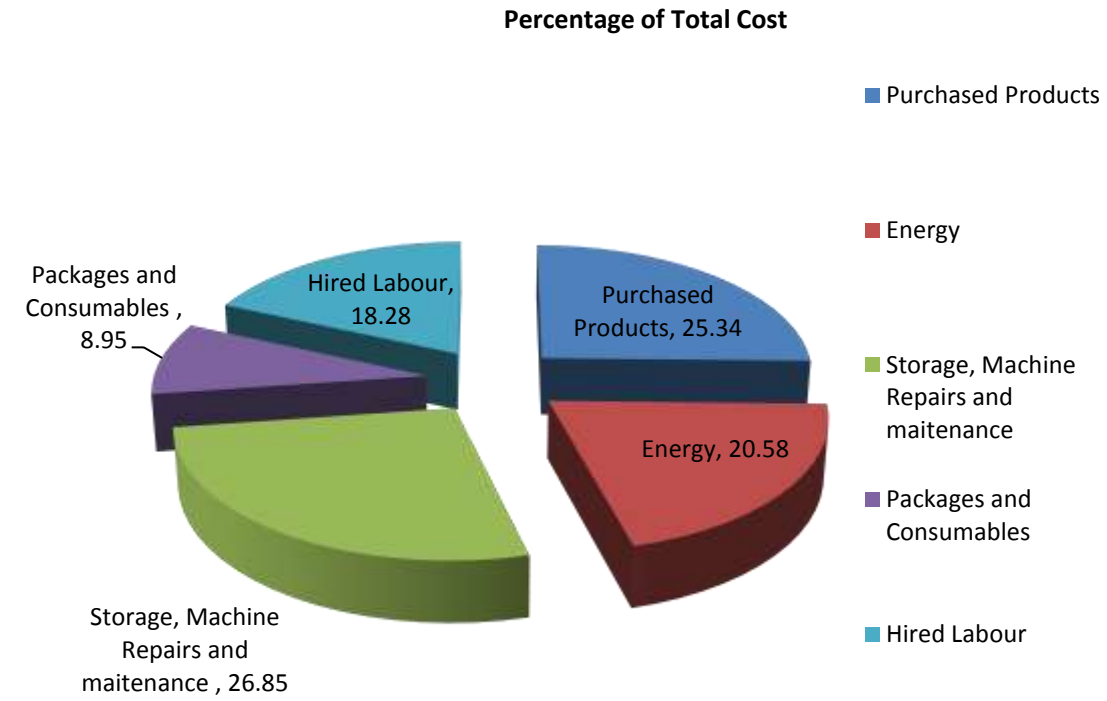

Figure 3. Build-up of financial cost at processing stage. Source: Author's computation.

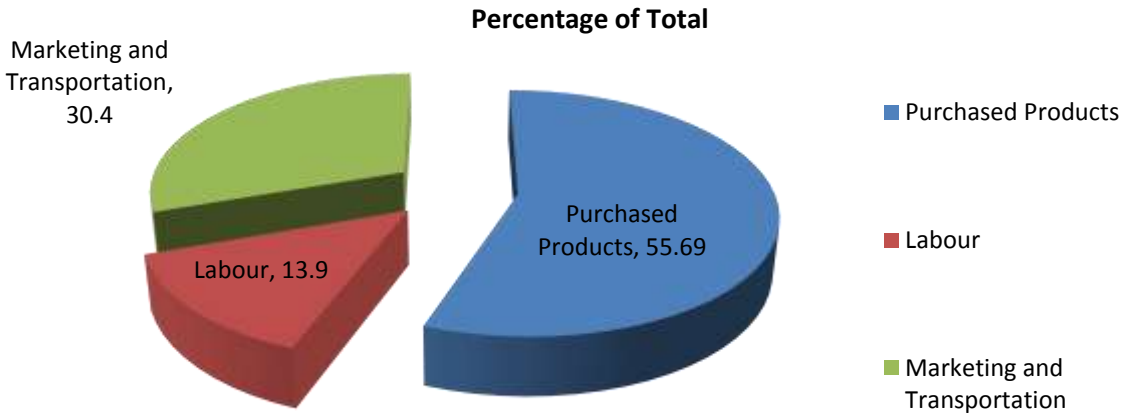

Figure 4. Build-up of financial cost at trading (logistics) stage. Source: Author's computation.

Financial costs and profitability indicators of sugarcane entrprises

The magnitudes of the financial cost and profitability indicators of sugarcane enterprise per metric tonne of product across the various stages of sugarcane value chain in Nigeria are summarised in Table 5. As shown by the table, each stage of the commodity chains is profitable. At the production stage, total production cost per metric tonne of output was ₦18,319.08 while the gross revenue realized was ₦31,230. Profitability indicators in terms of gross margin and net profit per metric tonne of commodity across the commodity chain are the lowest at the fam gate level. The gross margin at the farm gate level was ₦18,624.54 while the net profit was ₦12,910.92 per metric tonne of output. In terms of rates of returns, the gross rate of return 148% which is higher than that of processing and trading stage. The net rate of return was 70% which is higher than that of trading stage. At the assembly stage, the total cost of operation per tonne was ₦46,279.46, gross margin per tonne was ₦37,133.78 while the net profit is ₦33,920.55. The rate of return, 186%, at the assembly stage, is the highest across all stages, but the net rate of return of

Table 5. Indicators of Sugarcane Enterprise Costs and Profitability in Nigeria, Per Metric Tonne.

Category	Farm gate product	Assembled raw material	Processed raw material	Traded commodity white sugar
Total variable cost (TVC)	12,605.46	43,066.23	23,633	115,252.86
Total fixed cost (TFC)	5,713.62	3,213.23	2,023	3,000
Total cost (TC)	18,319.08	46,279.46	25,656	118,252.86
Gross revenue(GR)	31,230.00	80,200.00	48,000	174,000.00
Gross margin (GM)	18,624.54	37,133.78	24,367	58,747.14
Net profit (NP)	12,910.92	33,920.55	22,344	55,747.14
Gross rate of return (GM/TVC)	1.48	1.86	1.03	0.51
Net Rate of Return(NP/TC)	0.70	0.73	0.87	0.47

Source: Author's computation.

Table 6. Domestic resource cost indices for sugarcane production in Nigeria.

Locations	Scale of operation	DRC Indices
Niger State	Small Scale	1.6
FCT (Abuja)	Small scale	2.4
	Medium scale	2.7
Adamawa State	Small scale	2.8
	Medium scale	2.6
Aggregates (National)	Small scale	2.3
	Medium scale	1.8

Source: Authors' Computation. Underlying data derived from Field Survey, 2014.

73% on the basis of net profit is lower than that at processing stage. At the processing stage, total operation cost per tonne was ₦25,656, gross revenue was ₦48,000.00, while net profit per tonne was N22,344 with 103% gross rate of return on the basis of gross margin and 87% rate of return on the basis of net profit.

At the trading stage, total cost of operation per tonne of white sugar was ₦118,252.86 while the gross revenue was ₦174,000. The trading stage attracts gross margin per tonne of ₦58,747.14 while the net profit was ₦55,747.14 with 51% rate of return on the basis of gross margin and 47% rate of return on the basis of net profit. Across the various stages of the commodity chain, both the gross and the net rates of return are the lowest at the trading stage.

Competitiveness of sugarcane production

The results of the analysis of domestic resource costs (DRC) in the production of sugarcane at small and medium scales as shown in Table 6 yield coefficients greater than 1. As indicated earlier, if the DRC is lower than 1, then fewer local resources are required to generate a unit of foreign currency; hence the value of the product at the world market price is greater than the resource costs used in production. Therefore, as opposed to the rest of the world, the country uses its resources more effectively and thus has a comparative advantage in the production activity. However, if the DRC is greater than 1, more local resources are required to produce a unit of foreign currency and the country has no comparative advantage in that production activity. Thus, in the case of Nigeria, the result of the DRC analysis presented in Table 6 indicate that sugarcane production in Nigeria is not internationally competitive. The reasons that negatively affect international competitiveness of the commodity are discussed subsequently.

Sugarcane yield in nigeria and five largest cane producers in the World

Table 7 summarised the sugarcane yield per hectare in Nigeria as well as the yield in the five largest cane producing countries in the wold. At the international level, the yield of sugarcane in Nigeria is the least among the comparator countries, namely, Brazil, India, China, Thailand and Mexico. For the period beween 2002 and 2013, the yield levels was the highest in Brazil with the yield being 76 tonnes per hectare on the average. The

Table 7. Yield of five largest cane producers in the world compared to yield in Nigeria in tonnes per hectare.

Countries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Brazil	71	74	74	73	75	78	79	80	79	76	74	75	76
India	67	64	59	65	67	69	69	65	70	69	71	67	67
China	65	64	65	64	67	71	71	68	66	67	69	69	67
Thailand	61	67	58	48	51	65	71	72	70	76	77	76	66
Mexico	72	74	75	77	75	75	74	70	72	70	69	78	73
Nigeria	19	19	20	21	21	24	20	19	19	20	20	20	20

Source: FAOSTAT, 2015.

yield level in Mexico averaged 73 tonnes per hectare. The yield of sugarcane was the least in Nigeria with the average yield of 20 tonnes per hectare for the same period. This implies that the yield level in Nigeria was about one-quarter of the yield in Brazil. The ultimate ambition of Nigeria, therefore, is to reach the level of sugarcane development attained by these five largest cane producing countries if the profitability and international competitiveness of sugarcane will be enhanced in Nigeria.

Constraints and limitations to growth of sugarcane industry in Nigeria

Infrastructure constraints arising from inadequate policy implementation is a worrisome challenge that could limit the profitablility and international competitiveness of sugarcane. Results of the in-depth interview conducted at the savannah sugarcane processing factory in Numan, Adamawa State, revealed that the seeds planted by the contract farmers were imported from Sudan for multiplication. The sugar processing factory spent a lot on diesel to supplement energy supply. The fertilizer being supplied to farmers are inadequate and often they are being procured by the farmers at exorbitant prices. Moreover, the machines for processing cane into sugar at Numan were imported. Further it was revealed that the factory spent huge amount of money on custom duty and the bureaucratic procedure involved in clearing their machines at the port.

More importantly, small-scale farmers have been discouraged by the restricted number of mills available. Most of the farmers are far away from the mills. This represents an important disincentive for both producers and millers. Producers of sugarcane can only sell their products to the limited number of mills, reached at a very high transport costs. The problem has been aggravated by lack of high quality roads and lack of steady supply of electricity, conditions that exacerbate a poor investment climate particularly in the Nigerian rural sector. The results in Table 4 and Figure 3 on the structure of operational costs at the processing stage supported these findings. At the processing stage, the operational costs of processing sugarcane are dominated by energy and machine operations (47.43%). Similarly at the logistics stage, (domestic distribution) excluding the cost of purchased products, the cost of marketing and transportation to delivery point dominates the total cost of operation (30.4%). In spite of the various government policies to revive the energy sector, hours of electricity per day is limited to few hours resulting in huge expenditure being spent by Nigerians on fuel to power electric generating sets (Nigerian Tribune, 23 October, 2014 page 4). With the current change of government in May, 2015, the hours of electricity per day has increased but not yet at the required level that will enhance international competitiveness of Nigerian agriculture.

In summary several difficulties adversely affected the performance and growth in the sugarcane industry. In general the problems cut across the production, processing and marketing stages of the value chain. The main constraints included reliance on estate-based industrial cane production system which has been bedevilled with myriads of operational deficiencies and has thus hindered regular supply of raw materials to the sugar factories over the years. Low output price for industrial sugar-cane is another disincentive factor on the part of the farmers. This resulted into shifting of production resources away from industrial sugarcane to other remunerative crops such as cassava. Only few farmers have joined the estate-based out-grower schemes due largely to unattractive prices offered to farmers. Unattractive price discouraged farmers from out-growers schemes. Restricted market for sugar-cane has tended to discourage increased production by small-scale farmers. The mills available are too few compared to the number of farmers. Moreover, available mills are located close to few farmers and far away from several others; thus constituting great disincentive for both producers and millers. Whereas farmers growing chewing cane can sell their products at various markets, producers of industrial cane can only sell to the limited number of mills which in some instances can be reached at very high cost of transportation. Other constraints include reliance on imported cultivars for the estate-based production systems, low level of capacity utilization in existing sugar mills and inadequate and irregular supply of sugarcane to

the mills.

POLICY IMPLICATIONS AND CONCLUSION

Based on the findings of this study, the following policy strategies should be given priority attention in order to enhance value addition and growth of sugarcane industry in Nigeria.

Effective implementation of the concept of staple crop processing zone for sugarcane processing and marketing

Federal Ministry of Agriculture and Rural Development has come up with the concept of staple crop processing zone (SCPZ). Effective implementation of the concept for sugarcane processing will ensure increased value addition,reduce deterioration of sugarcane and ensure increased market access and market linkages. The processing zone will be helpful for processing sugarcane immediately after harvest. This will create incentives for producers, processors, and marketers along the sugarcane value chain and it will address infrastructure challenges such as poor roads, unreliable power supply, lack of processing, storage and marketing facilities, inefficient supply and poorly integrated supply chains and lack of off-takers for the produce of farmers that often lead to post-harvest losses.

Research institutes should develop improved and high yielding varieties of sugarcane

More improved seed varieties should be developed by the Research Institutes and should be made more available to farmers to improve on the low yields of sugarcane obtained in Nigeria. The Reseach and Technology Innovation Focus (RTI) of the National Sugar Development Council (NSDC) must continue to fund investment in Research and Development and must ensure development of high yielding, disease resistant and pest resistant as well as drought and flood tolerant variesties of industrial sugarcane through strengthening of existing relevant research institutes for raising the poor yield of sugarcane when compared with the five largest cane producing countries.

The Nigerian sugar master plan should be effectively implemented

The Nigerian Sugar Master Plan (NSMP) is a Road Map designed to make the Nigerian Sugar Industry transform into a world class multi-product sugarcane industry. The NSMP lays the ground for enhanced performance of the sugar industry premised on a robust import substitution stategy and attraction of investment through a liberal incentives and policies. The master plan if effectively implemented will address some of the constraints limiting the growth of sugarcane industry in Nigeria.

Development of physical infrastructures

Clearly, physical infrastructure, especially transportation is a major constraint for actors along sugarcane value chain. Deplorable rural road condition is thus a major issue for attention. Good roads will improve access to farms and to markets and will ultimately result in lower unit cost of commodities being purchased and transported. The recurring challenge of low sales and low patronage among farmers will be addressed when there are good roads that link village to village and villages to industrial centres in towns and cities. Investment in infrastructure and new innovative processing technology is required for the modernization and the expansion of local processing industries, as well as for enlarging markets for the outputs of sugarcane industries. Presently, there is weak linkage of farmers to processing factories.

The monopoly of the few sugar processing companies in the country should be broken

This can be done by looking for a technology that can make it possible even for the farmers to produce and process at small-scale level, just as being done in China and India in the case of cotton and apparel industry. There should be small scale processing machine adaptable by the farmers and processors on the small scale level. In this case, the issue of energy and transportation would be addressed so that farmers can engage in processing at reduced cost.

Conflict of Interest

The authors have not declared any conflict of interest.

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