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Endogenous Inputs Use as a Predictor of Internal Efficiency in Postgraduate Research Degree Programmes in Ghanaian Public Universities

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ABSTRACT: *Universities rely on endogenous inputs they have to enroll and train students to graduate. Studies have concluded that graduation rates are low at research masters and doctoral degree levels in universities. This study determined endogenous inputs uses which predict internal efficiency in postgraduate research degree programmes in two Ghanaian public universities. The study used data obtained from a sample of 318 research students and graduates from nine applied science and sixteen humanities departments. Stratified random and snowball sampling techniques were used to sample participants for the study. Questionnaires and documents analysis guides provided data to test hypothesis at p<.05 alpha level of significance. Faculty and students' interactions, use of study spaces, reading resources at departments and libraries are endogenous inputs uses which accounted for high levels of variation in graduation rates and significantly predicted research students' graduation rates. The study recommended among others that policy should be crafted aimed at increasing endogenous inputs uses in universities to ensure higher internal efficiency thus high students' graduation rates.*

KEYWORDS: endogenous inputs use, internal efficiency, graduation rate, postgraduate research degrees, universities

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INTRODUCTION

Higher education institutions refer to designated organizations providing postsecondary tertiary level education. They include traditional universities and profession-oriented institutions such as universities of applied sciences or polytechnics in Finland and technical universities in Germany. Alternatively, it is a level of education that is provided by universities, vocational universities, community colleges, liberal arts colleges, institutes of technology and other collegiate level institutions such as vocational schools, trade schools and career colleges that award academic degrees or professional certifications (Wang, 2017). Postgraduate education component of higher education refers to studies individuals pursue after they have obtained a bachelor's degree. It usually starts from the master's degree level and then to the doctoral degree level. However, there are other postgraduate qualifications like postgraduate certificates and diplomas (HEPI & BL, 2010). Postgraduate programmes in universities are regarded as the conduit through which research ability is nurtured. High skills are acquired to research and solve complex societal problems in order to facilitate a country's economic growth and development (HEPI & BL, 2010).

Olibie, Agu, and Uzoechina (2015) in a review article state that worldwide the postgraduate studies setting is going through speedy transformations with much focus on preparing students for research. The researchers posit that this is achieved through the imparting of knowledge and competencies that enhance postgraduate students' capacity to become innovative and self-sufficient in their research practice. This indicates that postgraduate education is focusing much attention on producing postgraduates who are competent to engage in the conduct of research due to the significant role that research plays in the progress and development of a contemporary society.

In a policy paper on the worth of research, the European Commission (2015) indicates that research has become increasingly productive as publications, citations, and discovery of new products increase. The commission notes that the economic worth of research goes far beyond the researcher. According to Jaffe (as cited in European Commission, 2015) economic worth of research can be explained in terms of spill over knowledge created by the researcher which is used by other agents.

Researchers in different fields are therefore churned out in higher education institutions such as universities, colleges and analogous institutions. Higher education institutions also train individuals in different fields with diverse skills and competencies to meet demands of the labour market. Higher education acquisition results in several benefits to individual graduate and the society as a whole. In this regard Brennan, Niccolo and Sene (2013) in a discussion paper about the wider non-economic benefits of higher education to the individual graduate and the spill-over effect on society, indicate that participation in higher education has resulted in many socialbenefits.

These social benefits include improved social cohesion, political stability and increased participation in local and national politics among others. The private benefits on the other hand include movement of individuals and families from lower social strata to higher social strata, greater life satisfaction and improved health among others.

The world's shift towards a knowledge economy in the 21st century, the increase in demand for higher education coupled with its rising cost against dwindling inputs or resources have put much pressure on universities to be extremely efficient in the use of inputs for teaching and research, retaining and processing of students to complete their degree programmes. Universities internal efficiency in the use of their scarce inputs, processing of more students and graduating the students saves cost and enhances the universities prestige (Crosling, Thomas & Heagney, 2009). However, researchers including Ashby (2004), Mutula (2009) and Amehoe (2013) Botha (2018) while reviewing articles on improving postgraduate research programmes completion and graduation rates maintained that postgraduate research students spend much long time on their studies to the extent that only some students persist and complete their study while others do not complete their study. Given that the universities have limited resources, this begs the question whether they are efficient in use of their scarce inputs in the preparation of postgraduate research degree students or not.

Some of the important endogenous inputs that universities use to support their teaching, research and supervision of students' captured in this write up focused on are physical facilities, Library resources and faculty. The study is situated in the context of dwindling resources to universities, need for universities to expand access in less developed countries especially, and the few research graduates universities churn out per cohort which signifies low internal efficiency against the need to churn out more research graduates to meet the needs of a contemporary society as well as satisfy sustainable development goal four.

Physical facilities are one of the endogenous inputs important to universities in their delivery of research, teaching and supervision of students' research. In the context of this study, the universities' physical facilities refer to their edifices, lecture and seminar rooms, laboratory equipment, and library resources and staff offices only. These physical facilities are significant and therefore attract much investment in many universities across the globe.

Focusing on research solely, the global research and development expenditure as a percentage of gross domestic product (GDP) continuous to increase at substantial pace in many countries with the current estimates putting the worldwide total research and development expenditure figure at 2.153 trillion US Dollars (NCSES, 2020, OECD, 2019). The research and development expenditure constitutes key endogenous inputs to support academic research in the universities. Figure 1 shows research and development expenditure as a percentage of GDP of selected countries.

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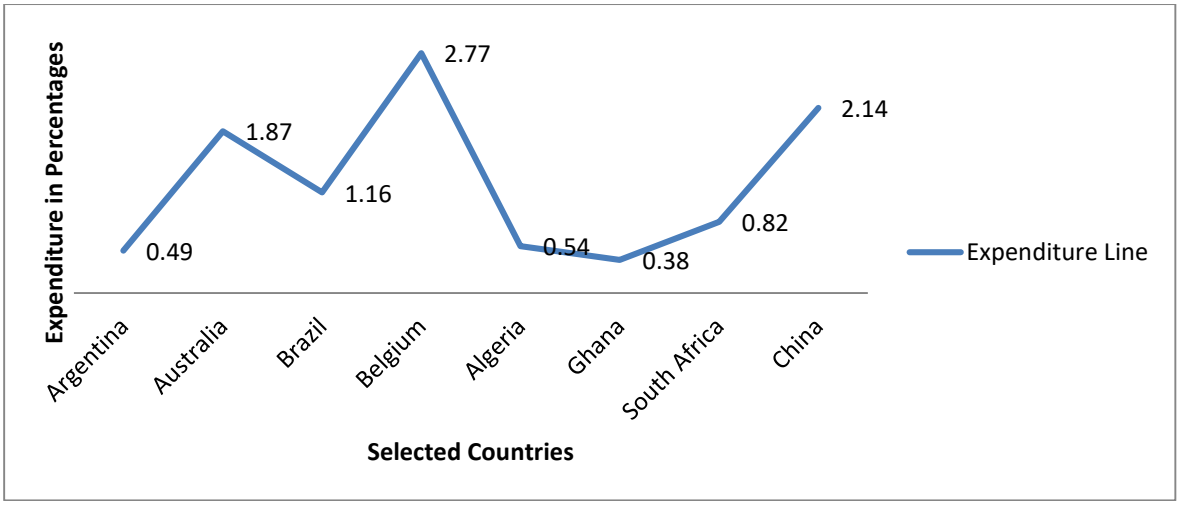

Source: UNESCO Institute for Statistics (2019/2020)

Figure 1: Research and Development Expenditure of Selected Countries

Figure 2 shows that Belgium made highest spending on research and development (2.77%). This was followed by China (2.14%), next was Australia (1.87%) followed by Brazil (1.16%). The remaining three countries are South Africa (0.82%), Algeria (0.54%) and Ghana (0.38%). These percentages of GDP spent on research and development by countries emphasized the importance of research and development in the modern world. The available data from these selected countries has not distinguished between expenditure on research carried out in universities and colleges from expenditure on research carried out outside academic institutions.

Another endogenous inputs significant to this study is the university staff comprising faculty and non-faculty members who interaction with postgraduate research students. Since faculty is very crucial to a university's output and status, universities maintain staff to keep up with teaching content and supervision of research and performance of administrative duties. Maintaining staff is very vital and expensive since it takes staff with high qualifications and expertise to produce the needed graduates in their numbers for a country. Countries, therefore, invest large sums of money in compensation of staff.

Specifically regarding research Figure 2 shows average monthly gross salaries of university faculty (researchers) from selected countries in US Dollars. The comparisons were done using purchasing power parity index PPP where earning were converted into actual goods and services money can buy.

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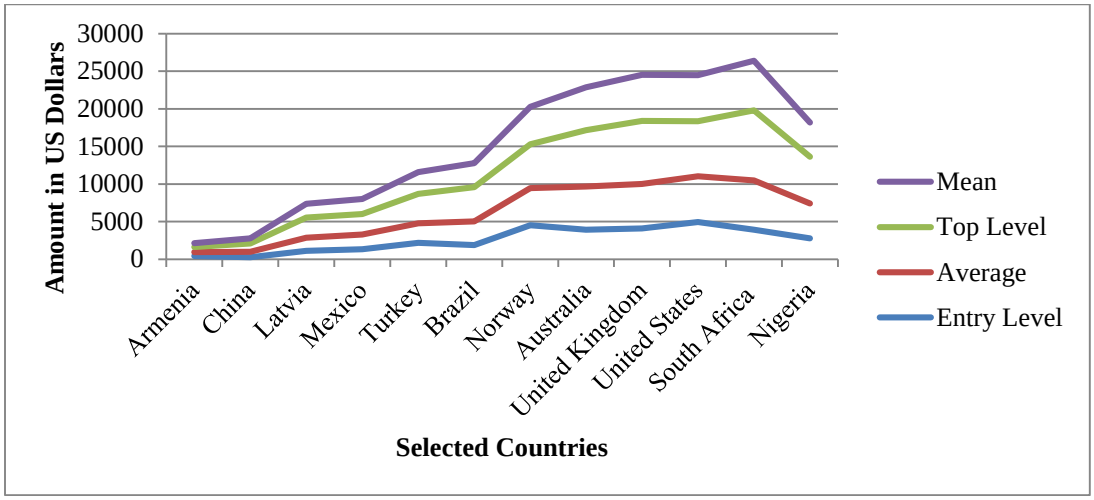

Source: Altbach et al (2012)
Figure 2: Monthly Average Salaries of Public Higher Education Faculty, Using Purchasing Power in US Dollars from 12 Selected Countries

Figure 3 shows the average monthly salaries of faculty members in US dollars at entry level, middle level, top level and mean earnings in selected countries' universities worldwide. Faculty in South Africa earned highest 6,596 followed by the United Kingdom 6,129.67, next was the United States 6,120.67, followed by Australia 5,714, next was Norway 4,992.67, next was Brazil 3,195.67. Other countries were Turkey 2,889.33 followed by Mexico 2,002, next was Latvia 1,842, followed by China 695.33 and Armenia 536. These average monthly earnings of researchers (faculty only) emphasized the importance governments of countries attach to research.

Although investment in postgraduate programmes and higher education in general as well as research and development in particular as evident in figures 1 and 2, there is high wastage depicting internal inefficiency in these programmes. This is illustrated in Ph.D. enrolment and graduation trends of two cohorts from nine selected countries as indicated in figure 3

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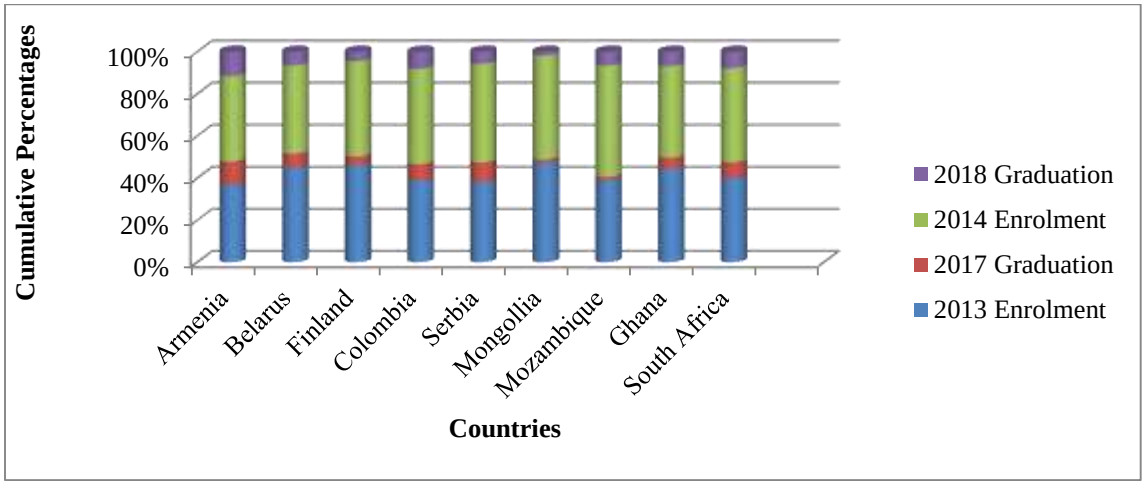

Source: UNESCO Institute for Statistics (2020)

Figure 3: Ph.D. Enrolment and Graduation Trends in Nine Selected Countries

Figure 3 shows the enrolment numbers of two cohorts, thus in 2013 and 2014 and their graduation rates in 2017 and 2018 respectively. The graduation statistics after four years period of Ph.D. programme as shown for 2017 and 2018 graduation rates are; Armenia 30.1% and 20.5%, Belarus 14.9% and 15.7%, Colombia 20.3% and 18.1%, Finland 10% and 10%, South Africa 19% and 17.5%, Mozambique 4.5% and 12.5%, Ghana 12.4% and 15.7%. These graduation rates demonstrate inefficiency in postgraduate programmes because they are far lower than 100%. In fact, the graduation rates are not up to 50% for any one of the nine countries showing low levels of internal efficiency as fewer graduates completed their study within scheduled duration per cohort.

These inefficient graduation rates support the assertion by the Council of Graduate Schools CGS (2008) in the United States that the number of doctoral candidates who complete their studies within seven years instead of four years was 46% of doctoral students admitted while 57% complete their studies in ten years' time period. As much as 23%, 28%, and 31% of the students dropped out in four years, seven years and ten years' time respectively. CGS (2008) noted that the high dropout rates and the low graduation rates of doctoral students are matters of great concern to stakeholders in the higher education community worldwide. McAlpine and Norton (2006) argued that low terminal degree completion rates lead to economic and intellectual loss to the individual students, their sponsors, the universities and the entire society. Evidence shows that in spite of the enormous benefits that accrue to society from research and the enormous resources invested into research globally, universities most especially in less developed countries experience internal inefficiency in production of postgraduate research graduates at the masters and doctoral degree levels.

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Statement of the Problem

In Ghanaian public universities many postgraduate research students spent time beyond the schedule duration for their programmes of study provided by universities policies. This study determined endogenous inputs uses that most significantly influence and predict postgraduate research degree study completion and graduation rate in the University of Ghana and the Kwame Nkrumah University of Science and Technology which account for more than halve of Ghana's postgraduate research graduates' production. This sought to bring such endogenous inputs uses to the fore and allow for more attention and resources to be focused on their use to facilitate postgraduate research students' study completion and graduation rate thus improve internal efficiency in these universities.

Purpose of the Study

The purpose of the study was to test the education production function model of Hanushek (1968) by relating educational inputs to internal efficiency in postgraduate research degree programmes in Ghanaian public universities and determined the extent to which endogenous inputs use predicts study completion and graduation rates in postgraduate research degree programmes in Ghanaian public universities. Null hypothesis "Ho: Use of endogenous inputs is not a statistically significant predictor of study completion and graduation rates in postgraduate research degree programmes in Ghanaian public universities" was tested.

The study was significant as it may have given a deeper understanding to key stakeholders in postgraduate education on endogenous input uses which most significantly facilitate and predict graduation rates at the postgraduate research degree level as well as inform policy in the universities about which areas of postgraduate research education should receive what amount of inputs and how to make maximum use of such inputs.

It however needs to be noted that the study relied on responses that respondents provided to determine the extent to which endogenous inputs use predicts graduation rates. To ensure extreme views do not affect outcome of the study data sources were triangulated.

Theoretical Framework

The study was modeled around the Education Production Function model developed by Hanushek (1968). According to the Education Production Function model, there is an association between school inputs and output measures such as academic achievement where the output is a function of the different inputs invested into the school system, in this case endogenous inputs (Hanushek, 1968; Hanushek, 1979). The education production function model is expressed as $Y= f(X_1... X_3, X_4...Xn,)$ where Y is the output produced of the products and Xs are the inputs invested into the school system. In this study, "Y" is the postgraduate research students' graduation rates, the Xs are endogenous inputs use in universities denoted by $X_I...X_{12.}$

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CONCEPTUALIZATION OF THE RELATIONSHIP BETWEEN ENDOGENOUS INPUTS USE AND INTERNAL EFFICIENCY/GRADUATION RATES

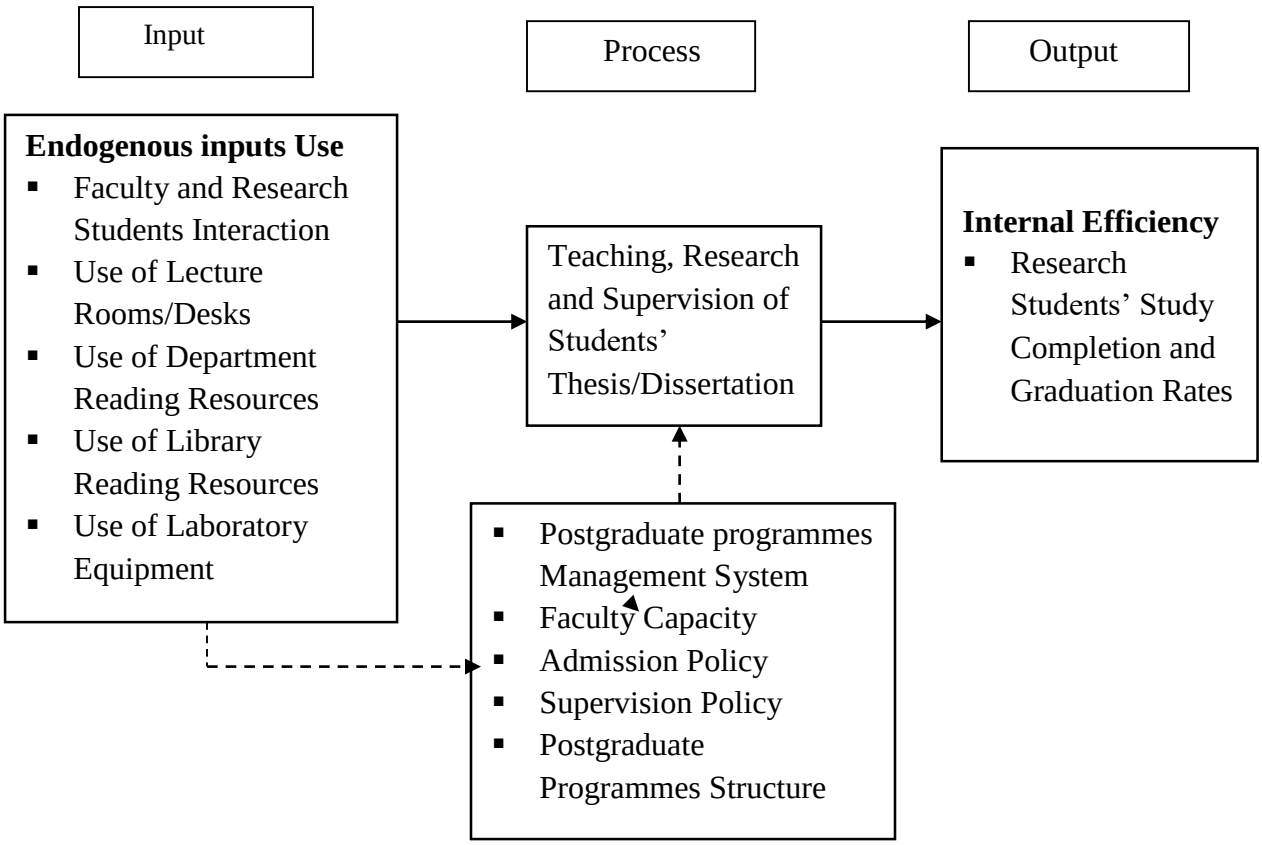

Figure 4: Conceptual Framework
Source: Researcher

The conceptual framework shows that endogenous inputs uses are the independent variables and inputs into the system. The endogenous inputs are faculty and research students' interactions, use of lecture rooms/desks, use of department reading resources, use of library reading resources and use of laboratory equipment by science students. Processing of the inputs takes the form of teaching and supervision of postgraduate research students works leading to in programmes completion and graduation of the research students. The programme completion and graduation rates constitute the dependent variable. Postgraduate programmes management system, faculty

capacity, admissions policy, supervision policy and programmes structures constitute the intervening variables.

METHODOLOGY

The study employed correlation research design, specifically principal component analysis and principal component regression to analyze data and report results. A sample of 255 MPhil and PhD students and 83 MPhil and PhD graduates sampled from two public universities in Ghana participated in the study. Stratified and proportionate random sampling techniques were used to sample the research students while snowball sampling technique was used to sample research graduates. Self designed questionnaires which had reliability coefficient above .7 and documents analysis guides that were validated by three experts served as the data collection instruments for the study.

Principal components analysis involve the derivation of principal components which are combination of the independent variables X_1, X_2, X_3,……Xn to come up with composite variables PC_1, PC_2, PC_3….PCn which aims to locate a small number of factors in a large sample of independent variables which account for a large variation in the data set. The Principal components are linear combinations of the independent variables (Xs) or the questionnaire items. Principal components measure what accounts for variation in the independent variable (endogenous inputs use). The principal component regression determined the graduation rates produced by the different endogenous inputs and takes the form: $Y= \beta_0+\beta_1PC_1+\beta_2PC_2+\beta_3PC_3……. \beta_ZPC_Z$ why Y is postgraduate research students study completion and graduation rate, β_0 is the constant or intercept, β_1 is the slope and PCs are the inputs in the model. One Way analysis of variance test determined if endogenous inputs use affect research students' degree programme completion resulting in differences in their graduation rates.

RESULTS

The study determined the relationship between endogenous inputs use and postgraduate research students study completion and graduation rate as well as the level to which endogenous inputs use predicts research students' graduation rate. Postgraduate research students' graduation rate was determined using the graduation figures for the academic years 2012/2013, 2013/2014, 2014/2015 for PhD and 2015/2016, 2016/2017, 2017/2018 for MPhil cohorts from the University of Ghana and the Kwame Nkrumah University of Science and Technology.

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INTER ITEM CORRELATION MATRIX

The study determined inter item correlation matrix and subjected the questionnaire items to principal component analysis (PCA). Table 1 shows the results of the correlation matrix.

Table 1: **Pearson Correlation between Endogenous Inputs Use Questionnaire Items**

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18
V1	1																	
V2	.48	1																
V3	.40	.58	1															
V4	.44	.41	.59	1														
V5	.34	.39	.48	.49	1													
V6	.14	.44	.40	.31	.33	1												
V7	.17	.41	.32	.26	.27	.23	1											
V8	.50	.36	.40	.46	.41	.40	.23	1										
V9	.32	.52	.55	.44	.44	.41	.35	.69	1									
V10	.17	.44	.38	.19	.35	.30	.51	.44	.57	1								
V11	.44	.40	.35	.47	.48	.37	.23	.54	.41	.43	1							
V12	.16	.41	.31	.17	.24	.26	.54	.18	.29	.48	.43	1						
V13	.09	.39	.25	.20	.31	.28	.42	.25	.26	.43	.39	.66	1					
V14	.07	.31	.24	.21	.23	.25	.53	.19	.21	.47	.37	.77	.71	1				
V15	.21	.38	.35	.38	.28	.35	.47	.27	.26	.48	.39	.65	.57	.76	1			
V16	.16	.25	.13	.33	.31	.31	.07	.27	.18	.10	.37	.03	.20	.15	.15	1		
V17	.37	.34	.36	.38	.45	.44	.10	.46	.41	.14	.49	.21	.32	.16	.15	.55	1	
V18	.39	.42	.41	.31	.27	.26	.25	.41	.51	.30	.27	.32	.23	.23	.31	.31	.36	1

n=318

*Correlations Coefficients (r) > 0.14 were significant at .05 alpha levels (Two-tailed)

The inter item correlations in Table 1 displays a number of significant correlations between participants responses or the questionnaire items. A good number of significant correlations between the questionnaire items suggest that the data can be summarized in few principal components. The determinant measured .007 >.001 rules out any issues of co linearity in the data, therefore, the data is suitable for principal component analysis (PCA).

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Prioritizing of Endogenous Inputs Uses That Facilitate Study Completion and Graduation from Postgraduate Research Degree Programmes

Prioritization of endogenous inputs uses involve using principal component analysis to determine the endogenous inputs use questionnaire items that contribute to high degree of variation in the data set. Prioritizing of endogenous inputs uses that facilitate postgraduate research students programmes completion and graduation starts with Kaiser Meyer Olkin (KMO) measure of sampling adequacy. This is followed by Bartlett's test of sphericity, factor loadings, commonalities, principal component analysis and principal component regression.

Factor Loadings, Communalities and Principal Component Analysis (PCA)

In this sub-section, ratings of the independent variable (endogenous inputs use) provided by respondents are subjected to principal component analysis to reduce redundancy in the data. The maximum common variance is extracted and accuracy of predicting the dependent variable (graduation rate of postgraduate research students) is increased. Principal component analyses allowed features of the 18 questionnaire items (variables) measuring endogenous inputs use to be reduced to fewer features and still measure the construct effectively (Gall et al 2003). The data was suitable for principal component analysis since the independent variable and the dependent variable produced continuous data and the assumption of normality and linear relationship between the variables were met. In addition, Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartett's test were also significant. The KMO and Bartett's Test results are in presented in Table 2.

Table 2: KMO and Bartett's Test of Sphericity

Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.83
Bartett's Test of Sphericity	Approximate Chi-square	1584.047
	Df	153
	Sig.	.001

α= .05, n=318

Kaiser-Meyer-Olkin measure of sampling adequacy in Table 2 recorded a significant value of .83 which is in line with the recommended .60 and more (Cerny & Kaisser, 1977; Dziuban & Shirkey, 1974; Kaiser, 1970). The Bartett's Test of Sphericity shows that the test value of (.001) was significant as this value is smaller than (α= .05; df = 153, significance = .001). This indicates the association between most of the questionnaire items (independent variables) used in the principal component analysis had positive linear relationship and there were no significant extreme values. The sample was also sufficient and therefore appropriate for PCA.

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The Communalities Extracted

The communalities extracted to show the proportion of shared variance in each item on the questionnaire (variable) accounted for by all other items combined are presented in Table 3.

Table 3: **Communalities Extracted Using Principal Components Analysis**

Variable	Initial	Extraction
V1. I used adequate study space in my department	1.00	.75
V2. I used reliable a reliable learning platform in my study	1.00	.65
V3. I used adequate library study space in my study	1.00	.76
V4. I used relevant reference books at the library	1.00	.78
V5. I used relevant online library resources on-campus	1.00	.63
V6. I used library resources off-campus online	1.00	.83
V7. I received sufficient thesis writing training	1.00	.81
V8. I received sufficient training in research methodology	1.00	.83
V9. I read enough completed thesis	1.00	.78
V10. I did enough presentation at thesis seminar	1.00	.73
V11. I received enough advice from the main thesis supervisor	1.00	.85
V12. I received enough guidance from the co thesis supervisor	1.00	.75
V13. I had regular contact with my thesis supervisors	1.00	.87
V14. I had regular feedback from my thesis supervisors	1.00	.75
V15. I used the hostel facility	1.00	.98
V16. I used a well laboratory	1.00	.93
V17. I received study support from colleague course	1.00	.78
V18. I read important journal articles	1.00	.51

n=318, Method of Extraction: Principal Component Analysis

Table 3 shows that 18 questionnaire items (variables) produced extractions measuring 0.51 and higher indicating important loadings since higher extraction values produce better results. The high extracted communalities represent the proportion of each variable being explained by the seven derived principal components in combination.

The Communalities and the Variances Explained

The communalities and the variances explained by each endogenous component can be seen in Table 4.

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Table 4: **Total Variance Explained by Each Endogenous Inputs Use as a Facilitator of Research Students Mean Graduation Rate**

Component	Initial Eigen values[a]			Extraction Sums of Squares		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.24	38.04	38.04	9.24	38.04	38.04
2	3.49	14.37	52.41	3.49	14.37	52.41
3	2.26	9.29	61.70	2.26	9.29	61.70
4	1.20	4.93	66.63	1.20	4.93	66.63
5	1.15	4.74	71.37	1.15	4.74	71.37
6	1.08	4.46	75.83	1.08	4.46	75.83
7	1.01	4.17	79.99	1.01	4.17	79.99
8	.85	3.51	83.51			
9	.73	3.02	86.53			
10	.59	2.43	88.95			
11	.52	2.18	91.13			
12	.52	2.14	93.27			
13	.42	1.72	94.99			
14	.33	1.34	96.33			
15	.30	1.24	97.57			
16	.22	.90	98.47			
17	.20	.82	99.28			
18	.17	.72	100.00			

n=318
Extraction Method: Principal Component Analysis
a. 7 Components Extracted

Table 4 shows the variance explained by each endogenous input use principal component. Each of the 18 endogenous input use questionnaire item generated one principal component and shows the variance explained by each principal component. Table 4 further displays the number of principal components and their matched eigen values and ranked the eigen values in order of magnitude from largest to the least eigen value where it can be seen that the largest eigen value is 9.24 and the least eigen value is .17. Table 4 shows the variance explained by each principal component while Table 5 indicates the questionnaire items that correlated with each of the seven generated principal components. Table 4 shows that out of 18 variables that facilitate research degree programme completion and graduation from public universities, seven derived components were extracted. The seven extracted principal components explained (79.99%) of variance in the data set. The contribution of each principal component and the number of components retained using the Eigen values greater than one rule was determined (Kaiser, 1970).

Table 4 shows that principal component one explained (38.04%) of variance in endogenous inputs use as a predictor of research degree completion and mean graduation rate with eigen value 9.24. Principal component two explained (14.37%) of variance in endogenous inputs use as a predictor of postgraduate research degree students study completion and graduation rate with eigen value 3.49. The third principal component accounted for (9.29%) of variance in endogenous inputs use

as a predictor of postgraduate research students programme completion and graduation rate with eigen value 2.26. Principal component four explained (4.93%) of variance in endogenous inputs use as a predictor of postgraduate research students programme completion and mean graduation rate with eigen value 1.20. The seventh principal component had an eigen value of 1.01 and accounted for (4.17%) of variance in endogenous inputs use as a predictor of postgraduate research students programme completion and mean graduation rate in Ghanaian public universities. This means the seven principal components extracted explained a large amount of variation in the independent variable. The remaining eleven principal components that were not extracted were not significant in predicting research students' mean graduation rate.

Rotated Component Matrix

Table 5 shows the seven generated principal components and illustrates the original variables or endogenous inputs use questionnaire items that had high correlation with each one of the seven extracted principal components.

Table 5: **Rotated Component Matrix of Endogenous Inputs Use**

Rotated Component Matrix							
Variable	Component						
	1	2	3	4	5	6	7
I had regular contact with my thesis supervisors	.93						
I received enough advice from the main thesis supervisor	.86						
I received enough guidance from the co thesis supervisor	.80						
I had regular feedback from my thesis supervisors about my thesis	.79						
I read relevant journal articles	.58						
I used relevant reference books at the library		.82					
I used relevant online library resources on-campus		.65					
I used adequate library study space in my study		.63					
I used adequate study space in my department		.55					
I did enough presentation at thesis seminar		.50					
I received sufficient thesis writing training			.76				
I received sufficient training in research methodology			.72				
I read enough completed thesis			.69				
I received study support from colleague course				.80			
I used a reliable learning platform to support my study				.52			
I used a well equipped laboratory					.81		.
I used library resources off-campus online						.82	
I used the hostel facility							.94

n=318
Extraction Method: Principal Component Analysis
Rotation Method: Verimax with Kaiser Normalization
Rotation Converged in 8 iterations
Coefficients less than 0.3 were suppressed

Table 5 indicates that a number of endogenous inputs use questionnaire items had high correlation with one of the seven generated principal components. Table 5 shows further that principal component one appears to measure faculty and students interaction. Questionnaire items that had high correlation with principal component one were; I had regular contact with my thesis supervisors (.93); I received enough advice from my main thesis supervisor (.86); I received enough guidance from my co-thesis supervisor (.80); I had regular feedback from my thesis supervisors about the thesis (.79) and I read relevant journal articles (.58) all loaded highly and moderately on or correlated well with principal component one.

Further, principal component two seems to measure research students use of library and department reading resources and study spaces and had high correlation with the following questionnaire items: I used relevant reference books at the library (.82); I used relevant online library resources on-campus (.65); I used adequate library study space in my studies (.63) and I used adequate study space in my department (.55). Principal component three appears to measure thesis writing training that research students receive from faculty and had high loadings or correlation with the questionnaire items; I received sufficient thesis writing training (.76); I received sufficient training in research methodology (.72) and I read enough completed thesis (.69).

Principal component four appears to measure support that research students receive from their colleagues and learning platforms and correlated highly with the questionnaire items or variables; I received study support from colleague course mates (.80) and I use reliable learning platforms to support my studies .52. Principal component five appears to estimate use of laboratory equipment by science students and correlated strongly with questionnaire items; I used a well-equipped laboratory (.81). I used library resources off-campus online (.82). Principal component six estimated use library resources off-campus online and correlates strongly with questionnaire items; I used library resources off-campus online .82. Principal component seven measured use of hostel facility and correlated strongly with the questionnaire item I use hostel facility .94.

Principal Component Regression of Endogenous Inputs Use and Postgraduate Research Students Mean Graduation Rate

The study determined if use of endogenous inputs predicts research degree programmes completion and graduation rate. Responses from MPhil degree participants and PhD degree participants were then summed up to address endogenous inputs use as a predictor of postgraduate research students study completion and mean graduation rate. To address the null hypothesis (H_o) the seven principal components that were extracted from endogenous inputs use through principal component analysis were regressed against the postgraduate research students mean graduation rate. The graduation rate at PhD degree level and graduation rate at the MPhil degree level for the graduating classes of 2017/2018, 2018/2019 and 2019/2020 were summed up and their mean determined and used as the postgraduate research students mean graduation rate. The correlation

coefficient (r) between endogenous inputs use principal components and postgraduate research students mean graduation rate as well as the coefficient of determination (R^2) helped to establish the percentage of variance in the dependent variable accounted for by the independent variable. The result of analysis of variance (ANOVA) showed the degree of freedom, the sum of squares as well as proved if endogenous inputs use affected research degree study resulting in significant differences in graduation rates.

Table 6: Regression of Endogenous Inputs Use Principal Components and Postgraduate Research Students Mean Graduation Rate

	R	R-Square (R^2)	Adjusted R^2	P-Value
Predictor Variable Endogenous Input Use Principal Components	.798	.637	.629	.001

P<.05,Dependent Variable: Research Students Mean Graduation rate

Table 6 shows that endogenous inputs use principal components correlate strongly with postgraduate research respondents study completion and mean graduation rates (r=.798, P<.05). This implies that as the universities make more use of their endogenous inputs, more postgraduate research students (PhD and MPhil respondents) complete their study and graduate from the public universities. The coefficient of determination (R^2=.637) indicates that the seven endogenous inputs uses principal components explained (63.7%) of variance in postgraduate research students mean study completion and graduation rates in Ghanaian public universities. The adjusted R square indicates that (62.9%) of research respondents graduation rate was attributed to the two endogenous inputs use principal components which had significant effect on postgraduate research students mean study completion and graduation rate. The significant endogenous inputs use principal components are principal component one PC_1 (faculty and postgraduate research students' interactions) and endogenous inputs use component two PC_2 (Use of department and library reading resources and study space). The remaining endogenous inputs use principal components, thus principal three PC_3 (thesis writing training that research students received from faculty), principal component four PC_4 (support students receive from their colleagues), principal component five PC_5 (used a well-equipped laboratory), principal component six PC_6 (used library resources off-campus online) and principal component seven PC_7 (I used the hostel facility) do not significantly affect research students study completion and graduation rates.

The Regression Coefficients

The regression coefficients (β) which indicates if a unit increase in any one of the seven endogenous inputs use components brings about any change in postgraduate research students graduation rate and if the change was significant or not is illustrated in Table 7. The model coefficients of each one of the seven endogenous inputs use principal components and postgraduate research students mean graduation rates are presented in Table 7.

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Table 7: Regression Coefficients of Endogenous Input Use Principal Components and Postgraduate Research Students Mean Study Completion and graduation rate

	Coefficients(β)	*Standard Error*	*t Stat*	*P-value*
Constant	-2.036	1.612	-1.263	0.207
PC1	1.942	0.090	21.614	0.000
PC2	2.234	0.338	6.616	0.000
PC3	0.151	0.308	0.491	0.624
PC4	0.305	0.249	1.222	0.223
PC5	0.250	0.353	0.709	0.479
PC6	0.191	0.374	0.511	0.610
PC7	0.210	0.260	0.807	0.420

***P<.05, Dependent Variable: Research Students Mean Graduation rate**

From Table 7 the study extracts the regression model or equation: $Y = -2.036 + 1.942PC1 + 2.234PC2 + 0.151PC3 + 0.305PC4 + 0.250PC5 + 0.191PC6 + 0.210PC7 + \epsilon$. This equation indicates that endogenous inputs use principal component one PC_1 (faculty and research students interaction) and endogenous inputs use principal component two PC_2 (use of library and department reading resources and study space) significantly affects postgraduate research programme completion and graduation rate. However postgraduate research students graduation rate is not significantly affected by the other endogenous inputs uses which are; endogenous inputs use principal components three (PC_3), endogenous inputs use principal component four (PC_4), endogenous inputs use principal component five (PC_5), endogenous inputs use principal component six (PC_6) and endogenous inputs use principal component (PC_7) since their significant values of 0.624, 0.223, 0.749, 0.610 and 0.420 are more than .05 respectively. This means that though PC_3, PC_4, PC_5, PC_6 and PC_7 have some effect on postgraduate research students' mean study completion and graduation rate, their effect is not significant statistically and hence described as having no significant effect on mean graduation rate of postgraduate research students.

The regression coefficients imply that, a unit increase in endogenous inputs use principal component one (PC_1) increases the postgraduate research students mean graduation rates by 1.942. A unit increase in endogenous inputs use principal component two (PC_2) increases postgraduate research students mean graduation rates by 2.234. A unit increase in PC_3 increases postgraduate research students mean graduation rates by 0.151. A unit increase in PC_4 increase postgraduate research students mean graduation rates by 0.505. A unit increase in PC_5 increases postgraduate research students mean graduation rate by 0.250 for the basic and applied science students only.

A unit increase in PC_6 increases postgraduate research students mean graduation rate by 0.191 and finally a unit increase in PC_7 increases postgraduate research students mean graduation rate by 0.210.

The constant in the regression model is -2.036 means that when endogenous inputs use components are zero postgraduate research students mean graduation rate decreases by -2.036. This is a clear indication that endogenous inputs or institutional resources use is a necessary condition for universities to produce postgraduate research graduates in their numbers. The regression weight Beta (β) in the model is the amount of change in the dependent variable (postgraduate research students mean graduation rate) when there is a unit change in the independent variable (endogenous inputs use components). The output from the regression equation means that endogenous inputs use component one PC_1 (faculty and student's interaction) and component two PC_2 (use of department and library reading resources and study space) are statistically significant predictors of graduation rates in postgraduate research degree programmes in Ghanaian public universities.

Analysis of Variance Test

An analysis of variance test was carried out to establish if endogenous inputs use principal components have a significant effect on postgraduate students study resulting in differences research students mean graduation rate as well as to show the sum of squares with the degrees of freedom. The analysis of variance test is shown in Table 8.

Table 8: **ANOVA Test on Endogenous Inputs Use Principal Components and Postgraduate Research Students Mean Study Completion and Graduation Rate**

	SS	***DF***	***MS***	***F***	***Sig.***
Regression	9148.417	7	1306.917	77.618	0.001
Residual	5219.726	310	16.838		
Total	14368.143	317			

P<.05, Dependent Variable: Research Students Mean Graduation rate

Table 8 shows that F(7, 310) = 77.618, is significant at P<.001. This means endogenous inputs use affect postgraduate research students study resulting in differences in their programme completion and graduation rates. It also implies the regression model fit the data, thus the independent variable (endogenous inputs use principal components) can significantly predict the dependent variable (postgraduate research students mean graduation rate). This means endogenous inputs use principal components are a statistically significant predictor of postgraduate research

students' graduation rate in Ghanaian public universities. The study therefore rejects the null hypothesis which states that use of endogenous inputs is not a statistically significant predictor of study completion and graduation rate in postgraduate research degree programmes in Ghanaian public universities and concluded that use of endogenous inputs is a statistically significant predictor of study completion and graduation rate in postgraduate research degree programmes in Ghanaian public universities.

DISCUSSION

The output of the regression equation in table seven means that endogenous inputs use component one PC_1 (faculty and students interactions) and endogenous inputs use component two PC_2 (use of department and library reading resources and study space) are statistically significant predictors of graduation rates in postgraduate research degree programmes in Ghanaian public universities. This finding supports the claim of Ibikunle and Akinola (2017) who reported that postgraduate research students rely on textbooks, reference materials, thesis and dissertation as well as journal articles as their reliable means of information to facilitate their study at the university. Further, the result is similar to the findings of Spronken-Smith and Quigg (2018) who found that research degree completion and graduation can be enhance through excellent thesis and dissertation supervision as well as providing students with research training. The finding further agrees with Lontchi (2018) who reported that accessibility to school resources in the form of teachers, well resourced libraries, learning aids, books and computers among others and their good use helps to improve school completion and reduce repetition and wastage in schools. This result further echo the voice of Yusoff (2015) who found that educational institutions' facilities influence learners' attitude and academic performance and therefore facilities needed to be accessible, adequate and attractive to boost students' performance and facilitate educational institution's output particularly in less developed countries. The finding also support Souck and Nji (2017) who found that there exist a statistically significant relationship between school facilities and schools internal efficiency and suggested that schools should be provided with more facilities to improve upon their internal efficiency. There is therefore enough evidence from this study to suggest that utilization of universities endogenous inputs like modern lecture and seminar rooms, well resourced libraries, electronic learning resources coupled with good faculty and students interactions facilitate postgraduate research degree programme completion and graduation rate among postgraduate research students and improve internal efficiency in Ghanaian public universities.

CONCLUSIONS

The study concluded that endogenous inputs use facilitates postgraduate research degree programme completion and graduation rate in Ghanaian public universities and account for a large amount of variation in postgraduate research students' graduation rates. Endogenous inputs use that most significantly facilitate and predicts research students programme completion and

graduation rates are research students' use of department study space, research students use of department reading resources, research students interaction with faculty, advice that research students received from theses supervisors, theses writing training that research students received from faculty, research students use of reading resources including textbooks, referred journal articles, theses and dissertation at the library and electronic resources online and science research students use of laboratory equipment. Endogenous inputs uses do not only facilitate postgraduate research degree programmes completion and graduation rate but are in fact a statistically significant predictor of postgraduate research students degree programme completion and graduation rate in Ghanaian public universities.

Implications

The implication of the results is that managements of public universities put innovative measures in place to ensure research students make more use of department study space and department reading resources through regular engagement. Increase faculty and students' interaction activities in the forms of regular supervisors' advice and feedback to supervisees, increase thesis writing seminars, workshops and conferences, increase use of library reading resources, space, use of reference books, reading of referred journal articles and thesis/dissertation within the physical library space and online. The results imply further that a policy to refurbish science laboratories regularly should be considered by management of public universities so as to ensure that the science laboratories have more modern and up to date equipment at all times in order to facilitate studies in the applied sciences programmes and to boost study completion and graduation rates among postgraduate research students in the applied science departments in Ghanaian public universities.

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