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Forecasting the Yield of Academic Software Investments in Nigerian Universities

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Abstract

This paper presents a mathematical model (with computer simulation) for forecasting the profits of buying software for the automation of established processes in the Nigerian University System. The mathematical model uses certain assumptions to provide a basis for iterative estimation of future income and the obtained results are intended to assist the management and stakeholders in deciding if investing in a software project is worthwhile.

Keywords: Nigerian universities, educational funding, software investment, forecast, yield, optimal decisions, return on investment (ROI), modeling.

1 Introduction and Problem Description

Every Nigerian university that is yet to automate one manual process or the other is apparently having the same set of challenges [1]. One major challenge is to determine if buying software for a process is necessary or if carrying out an in-house software project is worthwhile. Answering

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this question and making a decision can be very tough from a financial standpoint due to "laws of needs" and "scale of preference" and similar to most governmental organizations in Nigeria, the state and federal universities are also ill-funded and often depend largely on Internally Generated Revenue (IGR) to grow in size and strength [2,3]. This is also true for some privately owned, average tuition-paying universities as they are entirely privately-funded. Till this moment, many university stakeholders have also considered purchasing academic software as "acquisition of liability with risk" [4,5] rather than asset, owing to the cost of purchase, associated risks and operating demands of these software applications, such as: not making returns and requiring operational sites (such as data centers), periodic maintenance, upgrade fees levied by developers, domain subscriptions, and so on.

However, if certain assurance can be provided to aid decision making; if these software applications can be fashioned to produce returns and if a convincing forecast of future returns can be obtained, then we can perceive such a purchase as investing in an asset rather than continually spending on a liability. This way, stakeholders can be confident that even with an interest capitalized loan, the software will produce just enough fund in time to justify its implementation and hence its continuing existence.

This work employs mathematical modeling techniques to forecast the cash flows from the purchase of software hereby providing assurance to stakeholders in the university system for effective decision making. The developed model is presented in two compartments; population growth forecast and return on investment forecast. The first compartment enables us to predict the future population of an arbitrary Nigerian university while the second compartment attempts to predict the returns of the investment on software projects, given the instance population of the university as predicted by the first compartment.

In plain terms, we are asking two questions:

(i) What will be the future population (estimated) of a Nigerian university given the present population and assuming a constant growth rate?
(ii) How much return can we realize from a software investment in the university whose future size is predicted in question (i)?

To aid our estimations, we have made a number of assumptions that apply to the population growth estimation models (with constant growth rate) and epidemic models with demography presented by Daley and Gani [6].

Several similar methods have been employed over the years to predict the cash flow of different systems and projects [7]. Kim and Park [8] used a model to forecast cash flow in the planning stage of construction projects to ensure a liquid system throughout project's lifespan. Park et al. [9] also used a cash flow prediction model to estimate the future cash flow of construction projects with the development of a tool that helps contractors at the early stages of a project.

The remaining of this paper is organized as follows: in Section 2, we have identified the reasons why universities have to generate revenue internally and how software purchase can be a good instrument in this regard; in Section 3, we have described educational software purchase as an investment in Nigeria; in Section 4, we presented the norms of software investment decision making; in Section 5, we presented the model developed in this work; in Section 6, we displayed the results obtained from the simulations and in Section 7, we presented discussions and conclusions. Lastly, Section 8 highlights a few limitations of the described model that has been pinned down for future investigation. The tail end of this paper contains the list of references.

2 A Need for Revenue Generation in Nigerian Universities

The study of the need for Nigerian universities to be self-contained in terms of financial sustenance has been carried out by different researchers in the past. Okojie [10] has identified the major catalyst responsible for the rapid growth of universities, stating that the rapid increase in demand for tertiary education has led to increase in the enrollment of degree students over the years from inception in 1948 to 2012. Table 1 shows the enrollment and Fig. 1 depicts the exponential growth graphically.

Table 1. Degree students enrollment from inception

Year	Enrollment
1948	104
1960	1,395
1976	40,000
1988	172,000
2000	448,000
2012	850,000

Source: Okojie [10]

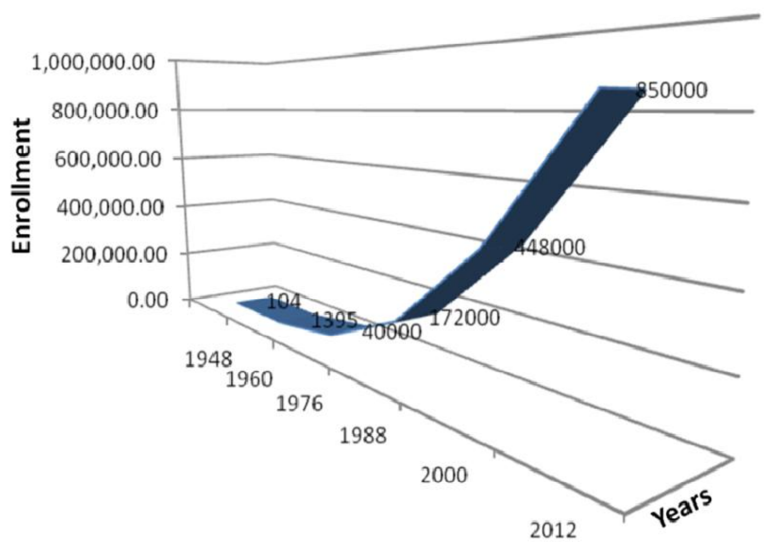

Fig. 1. Exponential growth of student enrollment in Nigerian universities

It has therefore become paramount for these institutions to generate internal revenue for self sustainability. Several methods are in common use for generating IGR. Zaid [11] describes the university library as a tool for generating funding. However, despite the efforts of these institutions, the inability to raise funds to meet their expenditure has raised concerns about quality of university education in Nigeria. In 2012, several private universities in Nigeria had their operational licenses suspended due to issues clustered around funding [12].

Okojie [10] enumerated the current challenges faced by the government in this regard, stating that the executive arm of Government provides budget capitalization that is based on estimations and projections from earnings. All sectors get this income including the educational sector which influences funding for the universities. However, this allocation has proven insufficient in recent years. The survey by Aboderin [13] stated that the Chairman of the Senate Committee on Education was not impressed that University of Lagos Nigeria made only ₦2.6bn from IGR[1], asking questions why a larger amount of income made was from student fees instead of other IGR mediums. This problem is the focus of this research as we have propounded a mathematical model that suggests software investment as another medium of IGR.

3 Academic Software Purchase as a Financial Investment

The major software modules deployed across several Nigerian universities are [5,14,15]:

(a) Students record management,
(b) Personnel records administration,
(c) Payroll system,
(d) Library automation,
(e) Semester courses registration,
(f) Online results checking,
(g) Result computation
(h) Hostel allocation and sometimes, the
(i) Electronic learning system.

These modules are often designed as self-contained applications but are habitually deployed in an integrated solution. Also, the ideal users of the resultant solution are often students and members of staff of the concerned institution. The common practice in the country (Nigeria) is that some of these modules attract charges from the student users. Students often purchase scratch/PIN (Personal Identification Number) cards to use these modules [5,16]. The modules that directly generate revenue for the university via pin card sales are: students record management, semester courses registration and result checking modules [5]. This is because the main users of these modules are students.

From a general perspective, investments are economic activities which are designed to increase, improve or maintain the productive quality of the existing stock of capital. In Finance, the idea of investment is a whole huge concept that this work does not investigate deeply into. We have simply brought to the table, academic software systems as financial instruments (similar to bonds, treasury bills, equity and so on), and proposing its tradability (buying and selling software in units) by forecasting its returns in future years.

[1] *Although not fixed, the conversion rate of Naira to US Dollar at the time of writing this paper is approximately: $1 USD = ₦162*

4 Software Investment Decision Making

Several articles have been published to address the issue of investment decision making, considering topics such as risk management, especially in finance. However, in Information Technology (IT), one notable work that addresses this issue is that of Ecar [17], suggesting that the task of making software investment decisions (deciding either to buy software or not) is often the responsibility of the management of the concerned organization and this process is often driven by perceived prospects of the investment.

This work looks at the university system in Nigeria and suggests a model for aiding its investment decision making process in purchasing academic software modules. The approached employed simply attempts to forecast the future yield (or returns) of the software applications to be purchased, taking into account quite a number of parameters which affects the real life system (such as population growth rate of the university).

5 A Model for Software Profit Forecast

In this section, we present a mathematical model for estimating the income the software modules highlighted in Section 3 will generate as a function of time, making certain "given" assumptions.

5.1 Model Assumptions

The following are fair assumptions, made from experience and statistically computed probabilities from related event that have occurred in the past.

We assume that:

(a) The software applications considered as means of revenue generation are: student record management, semester course registration and semester online result access modules.
(b) Only students pay for these facilities by purchasing scratch cards.
(c) The university population growth rate is constant as a function of time.
(d) Given that P_1 is the initial population of a university, the average yearly population growth is arithmetic and at a yearly increase rate of 10% of the previous year's population; with 15% increase for incoming students (or birth rate) and 5% reduction for graduating students (or death rate).
(e) Let R_n represent the returns made from scratch card sales after a given future year, n, and assume that the scratch card prices are set as follows:

    (i). ₦1000 per student for entry-level registration (once in a period of studentship),
    (ii). ₦500 per student for semester courses registration (twice annually; sums to ₦1000 per student) and
    (iii). ₦500 per student for semester online result access (twice as well; sums to ₦1000 per student/year).

(f) Not all students are interested in checking their results online (of course that is true in the real life scenario according to [5]). Let us assume 70% of the students in the system are interested and will patronize the online application.

5.2 Derivations

From assumption (d), we proceed to present a diagrammatic representation of the population model in Fig. 2.

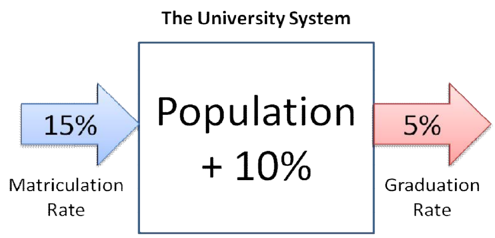

Fig. 2. University population growth model

As depicted in Fig. 2, the population grows at the rate of 10% annually. Using the simple population growth model, the population of the university after a specified year 'n' of software operation is given as:

$$P_n = P_{n-1} + 0.1P_{n-1}$$

$$\Rightarrow P_n = 1.1P_{n-1} \qquad (1)$$

$$P_0 = 0;\ P_1 \ is\ given$$

Where P_0 is the population of the University at time to and P_1 is the assumed starting population of the University at time T_1.

From assumptions (e) and (f), in the first year, every student will register their personal record online and also use the course registration module hereby paying ₦2000 per head and ₦1000 per head for 70% of the population only: therefore;
For year n = 1, return is given as:

$$R_1 = 2000P_1 + 0.7 \times 1000P_1 \qquad (2)$$

Simplifying equation (2), we have;

$$R_1 = 2700P_1 \qquad (3)$$

In subsequent years, only incoming students (15% of the entire population) will use the students' records module while the entire population will still use the other modules, hence:
For n > 1, the return after year n is given as:

$$R_n = R_1 + \sum_{n=2}^{k}[1000P_{n-1} + 2000(0.15)P_n + 0.7 \times 1000 \times P_n] \qquad (4)$$

Simplifying equation (4), we have:

$$R_n = R_1 + \sum_{n=2}^{k} 1000[P_{n-1} + P_n] \quad (5)$$

Where k is the number of years we are estimating for, R_1 is the return for first year calculated in equation (3), P_n is evaluated with the equation in (1), $P_0 = 0$ and P_1 is the given initial population.

6 Model Implementation, Simulation and Results

6.1 Model Implementation

The model developed in this work was implemented with a console application with Java programming language. The population and returns equations in (1) and (5) were compactly and programmatically expressed using recursive constructs and several iterations were generated to check the behavior of the model using different initial values or starting points for university population, bench-marked against software investment. Algorithms 1 and 2 describe the model implementation.

The function in Algorithm 1 takes as input: the number of years, n; and the initial population of the university, P_1. It returns the predicted population in a future year, n. The underlying formula used in the prediction is the numerical scheme presented in Equation 1. Similarly, the function described in Algorithm 2 takes the same set of parameters, (n and P_1) and outputs the Return on Investment (ROI) after a given year n using the population function in Algorithm 1 for its prediction.

Algorithm 1. Population function

```
Real Function getPn(n, P1: Integer) {
  Variables: Pn As Real
  If n = 0 Then
    Pn = 0
  ElseIf n = 1 Then
    Pn = P1
  Else
    Pn = 1.1 * getPn(n - 1, P1)
  End If
  Return Pn
}
```

Algorithm 2. Return on Investment (ROI) Function

```
Real Function getRn(n, p1: Integer) {
 Variables: Rn, sum As Real, i As Integer
 If n = 1 Then
   Rn = 2700 * p1
 ElseIf n >= 2 Then
   sum = 0.0
   For i = 1 to n
         Sum += 1000*(getPn(i - 1, p1)+getPn(i, p1))
   Next i
   Rn = getR1(p1) + sum
 End If
 Return Rn
}
```

6.2 Simulation and Results

In this section, we present the report of simulations carried out using different initial starting points for population and varying length of years to arrive at predicted ROI values respectively. The algorithms described in (1) and (2) were expressed in a computer program and iterative results were generated.

The subsequent tables show a simulation of three case-scenarios: best case, average case and worst case. The best case scenario is considered as a situation whereby the university's initial population is very high (say between 15 to 20 thousand) and the amount spent on the purchase of software is very low (say ≤ 15 million naira), the average case scenario is a midpoint in population (say between 10 and 15 thousand students) with an investment of about 15 to 20 million naira) and the worst case is assuming that very few students are contained in the system (say less than 10 thousand) with a very high investment rate on software (say about 30 million naira); all at time $t_{0.}$ Table 2 shows these scenarios with a pivot-tabular display.

Table 2. Scenarios for model testing

	Best case	**Average case**	**Worst case**
Population (in thousands of students)	15 – 20	10 – 15	< 10
Software Investment (in Millions of Naira)	≤ 15	15 – 20	≥ 30

Subsequently, we have presented iterative results from these three categories in the following subsections.

6.2.1 Best case simulation results

Using:

Initial population P_1 = 16,500 students
Software investment = ₦15,000,000
Number of years (iterations) = 20

6.2.2 Average case simulation results

Using:

Initial population P_1 = 12,500 students
Software investment = ₦19,500,000
Number of years (iterations) = 20

6.2.3 Worst case simulation results

Using:

Initial population P_1 = 2,500 students
Software investment = ₦35,000,000
Number of years (iterations) = 20

The computed estimates shown in Tables 3, 4 and 5 are compared with respect to the percentage of profit realized from these scenarios and a comparative analysis is presented in Fig. 3.

Table 3. Iterative results for best case scenario

Year (n)	Population of University (P_n)	ROI from inception (R_n)	Percentage profit (%)
1	16,500	44,550,000.00	297.00
2	18,150	79,200,000.00	528.00
3	19,965	117,315,000.00	782.10
4	21,962	159,241,500.00	1,061.61
5	24,158	205,360,650.00	1,369.07
6	26,574	256,091,715.00	1,707.28
7	29,231	311,895,886.50	2,079.31
8	32,154	373,280,475.15	2,488.54
9	35,370	440,803,522.67	2,938.69
10	38,907	515,078,874.93	3,433.86
11	42,797	596,781,762.42	3,978.55
12	47,077	686,654,938.67	4,577.70
13	51,785	785,515,432.53	5,236.77
14	56,963	894,261,975.79	5,961.75
15	62,659	1,013,883,173.37	6,759.22
16	68,925	1,145,466,490.70	7,636.44
17	75,818	1,290,208,139.77	8,601.39
18	83,399	1,449,423,953.75	9,662.83
19	91,739	1,624,561,349.13	10,830.41
20	100,913	1,817,212,484.04	12,114.75

In Fig. 3, it is shown with the aid of a bar chart that the percentage of the invested money realized continuously increases with the year of software operation. It is also apparent that the best case scenario produces approximately 100% more returns than the average case scenario. The worse case on the other hand yields just enough returns to justify the existence of the software.

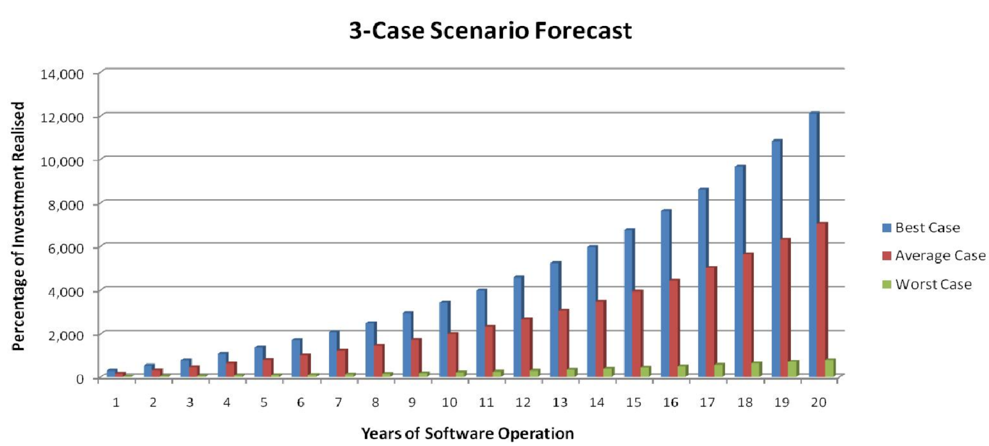

Fig. 3. Comparison of best, average and worst case scenarios

Table 4. Iterative results for average case scenario

Year (n)	Population of University (P_n)	ROI from inception (R_n)	Percentage profit (%)
1	12,500	33,750,000.00	173.08
2	13,750	60,000,000.00	307.69
3	15,125	88,875,000.00	455.77
4	16,638	120,637,500.00	618.65
5	18,302	155,576,250.00	797.83
6	20,132	194,008,875.00	994.92
7	22,145	236,284,762.50	1,211.72
8	24,359	282,788,238.75	1,450.20
9	26,795	333,942,062.63	1,712.52
10	29,475	390,211,268.89	2,001.08
11	32,422	452,107,395.78	2,318.50
12	35,664	520,193,135.35	2,667.66
13	39,231	595,087,448.89	3,051.73
14	43,154	677,471,193.78	3,474.21
15	47,469	768,093,313.16	3,938.94
16	52,216	867,777,644.47	4,450.14
17	57,438	977,430,408.92	5,012.46
18	63,181	1,098,048,449.81	5,631.02
19	69,499	1,230,728,294.79	6,311.43
20	76,449	1,376,676,124.27	7,059.88

Table 5. Iterative results for worst case scenario

Year (n)	Population of University (P_n)	ROI from inception (R_n)	Percentage profit (%)
1	2,500	6,750,000.00	19.29
2	2,750	12,000,000.00	34.29
3	3,025	17,775,000.00	50.79
4	3,328	24,127,500.00	68.94
5	3,661	31,115,250.00	88.9
6	4,027	38,801,775.00	110.86
7	4,429	47,256,952.50	135.02
8	4,872	56,557,647.75	161.59
9	5,359	66,788,412.53	190.82
10	5,895	78,042,253.78	222.98
11	6,485	90,421,479.16	258.35
12	7,133	104,038,627.07	297.25
13	7,847	119,017,489.78	340.05
14	8,631	135,494,238.76	387.13
15	9,494	153,618,662.63	438.91
16	10,444	173,555,528.89	495.87
17	11,488	195,486,081.78	558.53
18	12,637	219,609,689.96	627.46
19	13,900	246,145,658.96	703.27
20	15,290	275,335,224.85	786.67

7 Discussion and Conclusion

Generally, investors (and stakeholders alike) sometimes think like "money-doublers" and often understand profits from the perspective of percentages. In this paper, we have seen that the cash flow (from investing in educational software in Nigerian universities) grows exponentially and could even reach a peak of about 12,000% profit on the invested value, if best case is achieved within a period of 20 years – *this is huge*.

However, the model described in this work is dependent on the dynamics of the underlying system. There are quite a number of actors involved in decision making in the Nigerian University (such as the Nigerian Universities Commission (NUC), Governing Council, Senate and sometimes Information Technology Units) and deciding to purchase software owing to forecasts like this may not be a viable decision due to lots of other reasons of political, administrative or non-business nature. Therefore, from an investor's (or software vendor's) perspective, a desire to supply software by proving its essentiality using these figures may not always be a "magic spell".

Furthermore, a "bigger picture" to look at involves some other considerations such as software maintenance and upgrade cost; if we are forecasting for a tenure of 20 years, we also have to consider the "slacks" and "scope-creep" issues – software will need to grow and someone has to bear the cost. Similarly, business environments in the real world also enforce certain standards such as: signed contracts and LOEs (letters of engagements) that bind agreements and were not discussed in this work.

Finally, the significance of this research is strong and crucial to the national growth of the country (Nigeria) with regards to the automation of system processes in the higher education and information technology in sectors. It is sad to note that till this present day, very few institutions in the country are technologically advanced enough to have: surveillance cameras in strategic locations on campus, access card restrictions to secured facilities, energy to run scientific equipments 24/7 and scalable software systems for established processes [18,19,20,21,22]. For some universities, a fire disaster will mean total loss of over 40 years of academic records that goes back from inception – this is an issue. Buying educational software in this context is desirable and of course, it is an obvious "*gold mine*". The question is: who pays for it when a university is incapacitated? This work is intended to serve as an assurance for private investors to put fund into educational software investment with optimism (and low risk) of future returns, thereby bringing forward the long awaited advancement for the Nation; this is considered a win-win situation for both parties, Universities and Investors alike.

8 Future Work

Sequel the model presented in this paper, the following are a number of directions pinned down for further investigation.

(a) Open-Source Development: This research has not considered the variability generated from the idea of Open-source development of Software. However, our background investigation shows that this is not a trend within the country [5]. Notwithstanding, it will be interesting to see the formulation of a varied model that considers this phenomenon.
(b) Cost of Software Operation: Buying software is not a once-off process. Most software systems often require maintenance, upgrades, and training which in turn increases the

cost of the system. An introduction of variables that will attempt to estimate how much goes into maintenance and upgrade will also be worth investigating.

(c) Population Growth Modeling: The model presented in this work was based on the assumption that population growth within the described system is at constant rate. This may not always be true. We hope to expand on this theory, using statistical data to estimate the growth rate in our further investigation.

Competing Interests

Authors have declared that no competing interests exist.

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