Funding-based Productivity Decision Support System for SMEs

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***Abstract*—Many Small and Medium Enterprises (SMEs) in developing economy are moribund in delivering quality services to customers. Funding as one of the key ingredients that influences service productivity is limited to acquire and hence the need for a decision support system to help in taking funding alternative decisions- highly adequate, adequate, and low. The stated funding alternatives determine the levels (high, moderate, or low) of service productivity of the SMEs. The product demand rate is also critical for the effective determination of the sustainable level of productivity. The new system has solved the problem of funding in the industry by relaxing the rigid traditional productivity system with inclusion of alternative levels of funding. The results of the study showed that the new system was robust and flexible in evaluating the productivity performance indices of the enterprises at different funding and demand probabilities. Results generally showed low productivities (less than 0.4) in most of test cases, but they were adequate to cater for the levels of demands in the enterprises. The practical implication of the outcomes of the system showed that the existing productivity and funding levels were sustainable in the SMEs for the prevailing demand quantities.**

***Index Terms*—Productivity in SMEs, funding, demand, decision support system**

I. Introduction

PRODUCTIVITY in the manufacturing sector has been constrained by many factors which include the following: low level of technology, low level of capacity utilization, low investments, high cost of production, inflation and inadequate infrastructure. It is on this basis that nowadays most government policies and initiatives aimed at developing the economy have focused primarily on the development of the small and medium enterprises [4], [7]. Due to the complexities involved in constructing productivity index, fewer data on productivity are available in many manufacturing sectors. The available data have indicated low level of productivity in the sectors [22]. Some manufacturing associations also confirmed the slow trend of productivity improvement [6], [13]. In the absence of data on productivity in the sector, data on other indicators of performance can be reviewed [9], [10]. These include production annual growth rate, capacity utilization rate and sub-sector's share in the Gross Domestic Product (GDP) [14].

Limited funds had made it difficult for firms to make investments in modern machine, information technology and human resources development, which are critical in reducing production costs, increasing productivity and improving competitiveness [16], [19]. Therefore, for industrial sustainability, a funding-based productivity measuring system is required for manufacturing enterprises to take into account the size of financial opportunity they can harness. Therefore, this paper identifies and relates the factors affecting productivity in the small and medium enterprises (SMEs), and develops and implements a productivity index measuring system for the sectors. The degree of productivity index will determine the impact of outputs on the economy. It is generally known that more grants will attract high degree of productivity, while at less grants productivity is expected to slow [24], [27], [31]. The good management decision is to strike a balance between productivity, funding and demand. A balanced productivity with funding should be able to bring about moderate production cost that will satisfy the customers. Therefore, productivity of SMEs that satisfies the need of the customers is important to the sustainability of the system.

The goods and services are the output of the enterprises. Enterprises produce goods and services for sale with the aim of making return/profit on their investments. In the process of production, an enterprise makes use of scarce resources which are called factors of production, namely land, raw material, labour and capital. The stated factors are generally referred to as inputs into the production process and the outputs are determined from returns generated by the enterprise [3]. How to combine the inputs to have a maximum result (optimal output) is the problem to be resolved by productivity [30]. Besides, the production output should be controlled to meet the requirements of the customers. Productivity can be computed for a firm, industrial group, the entire industrial sector or the economy as a whole. It measures the level of efficiency at which scarce resources are being utilized. Higher or increasing productivity will, therefore, mean either getting more output with the same level of input or the same level of output with less input. The productivity formulae given in literature [30] can only be used to determine in-house productivity index because they are deficient of external influencing factors such as external aids/supports. In this study trade-off between increased funding on SMEs and productivity will be determined by balancing the production cost with the level of customers' patronage.

Productivity improvement techniques were also studied in some quarters. These include: technology based (computer-aided design and manufacturing, computer integrated

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manufacturing system, robotics, laser technology, modern maintenance technology, energy technology, flexible manufacturing system, etc.); employee based (incentives, promotion, job design, quality cycle, staff welfare, etc.); material based (material planning and control, waste elimination, recycling and reuse of waste material, purchasing logistics, etc.); process based (method engineering and work simplification, process design, human factor engineering, etc.); product based (reliability engineering, product mix and promotion, value analysis/value engineering, etc.); management based (management technique, communication, work culture, motivation, promoting group activity, team work, etc.) [11], [12], [18], [25], [26], [33]. This study develops a decision support system to facilitate optimal selection of strategies for an improved productivity based on funding and demand levels. Olorunsola [21] observed that small enterprises are most likely to face grants rationing because most potential lenders have little information on their managerial capabilities. McKinnon [17] and Shaw [28] emphasized the importance of internal and external finances in the productivity improvement of the manufacturing sub-sectors. Unfavourable environment has hindered financial institutions from granting adequate fund to manufacturing sub-sectors [1], [2], [5], [21], [26], [32]. Manufacturing activity can only flourish in a good investment climate. Features of the investment climate such as physical infrastructure, financial markets, and the governance conditions create the enabling environment for investment and determine the opportunities and incentives for firms to invest productively [6], [8], [17]. Many studies have treated productivity of manufacturing enterprises and the granting of loans by financial institutions as a separate entity [4], [21]. The traditional methods of productivity performance index measurement utilized in the identified studies did not take into account the uncertainty in the release of funds to the industries [3]. In this study, probability of releasing fund to the manufacturing enterprise will be considered, and at the same time balance the levels of funding with productivity and volume of demands.

II. Research Methodology

A. Productivity Modelling

Factors affecting the productivity of SMEs were identified. Mathematical relationships among the identified factors were formulated using conventional/traditional productivity approach. A probability based productivity model was developed using financial uncertainty constraint, and this was integrated into the traditional productivity system. Financial uncertainty was analysed using β-probability distribution and the outcome was applied in the new model. Three categories of generating fund namely; shares, grants and loans were utilized. Data on funding through shares were directly obtained from individual and group. Data on other supports were obtained from publicly and privately owned financial institutions (agencies). The aforementioned data were classified as optimistic, most likely and pessimistic modes of funding based on accessibility and condition of award. Given that $Q_{o,t}$ is the output in tonnes, $L_{o,t}$ is the total labour, material, and capital input in tonnes, with o,t represents the base period and the current period, respectively. Then the traditional productivity index model Q_{dt} is [13], [20]:

$$Q_{dt} = \frac{Q_t}{L_t Q_o L_o} \quad (1)$$

The traditional deterministic model was modified to probabilistic productivity index model to take care of productivity uncertainty and expressed as

$$Q_{pt} = P(t) Q_{dt} \quad (2)$$

where,

Q_{pt} = productivity based on actual funding over expected funding at time t

Q_{dt} = productivity based on traditional approach at time t,

$P(t)$ = probability of actual funding over expected funding at time t.

Probability of actual funding over the expected funding can be obtained from:

$$P(t) = F_{actual}/F_{expected} \quad (3a)$$

F_{actual}= the amount of money available for production at the base period, o.

$F_{expected}$ = the amount of money expected for production at current time, t.

Funding uncertainty (incapability) of the SMEs was analysed using β -distribution [15], [23]:

$$F_{expected} = \frac{F_{op} + 4F_m + F_p}{6} \quad (3b)$$

F_{op} = optimistic fund release at time t

F_m = most likely fund release at time t

F_p = pessimistic fund release at time t.

Total productivity increase based on improvement in release of funds at time t, was analysed using dynamic system based on modified growth function,

$$Q_{pt}^{T} = P(t)[P(t)' + 1]^T Q_{dt} \quad (4)$$

$[P(t)']$ = probability of productivity change with increased funding at a time t.

With the consideration of a scalar random variable (demand) quantity, Q, based on Gaussian (normal) probability density function (PDF) [15], [29], the probability of demand change with change in productivity and funding, $P(Q)'$ is;

$$P(Q)' = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2\sigma^2}(Q-\mu)^2\right] \quad (5)$$

where, μ the mean of quantities demanded Q and σ^2 is the variance of Q

Therefore, equivalent productivity at this demand can be modelled from equation (4) and expressed as equation (6)

$$Q_{pt}^{T'} = P(t)[P(Q)' + 1]^T Q_{dt} \quad (6)$$

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Optimal productivity index was determined based on the trade-offs between Q_{pt}^{T} and $Q_{pt}^{T\prime}$ that meet the conditions of funding and demand thresholds (equation 7).

B. Study Samples

Small and medium enterprises were used for this study because they are more accessible and tend to have problem of getting funds or grants from financial agencies. Sachet water and vegetable oil factories located at Ibadan, Nigeria were the two small and medium enterprises used as study cases.

C. Decision Support System

The data collected from the stated factories were analysed statistically based on the stated formulae. The outcome data were used as input parameters to the traditional model in estimating time-based productivity indices, Q_{dt} (equation 1) and the newly developed model based on Beta-probability distribution, Q_{pt} (equation 4). The input parameters include initial and final output quantities (tonnes) (Q_o , Q_t) initial and final capital, labour and material input (tonnes) (L_o , L_t). The determination of productivity index for both approaches was carried out using the modified Linkert-scale (Equation 7). The decision rules (threshold values) were applied based on established facts from the enterprises, and are mathematically represented by:

$$if \begin{cases} 0.7 \le Q_{pt}^{T} \le 1, & high\ level\ funding \\ 0.5 \le Q_{pt}^{T} \le 0.6, & moderate\ level\ funding \\ 0 \le Q_{pt}^{T} \le 0.4, & low\ level\ funding \end{cases} \tag{7}$$

The values of $Q_{pt}^{T\prime}$ will decide whether the funding condition given by equation (7) is optimal (true) for the demand cases or not;

$$if\, Q_{pt}^{T\prime} \begin{cases} = Q_{pt}^{T}, & true \\ \neq Q_{pt}, & otherwise \end{cases} \tag{8}$$

III. Results and Discussion

Tables I and II give the outcomes of the model using traditional approach as applicable to the selected SMEs namely; vegetable oil processing and sachet water factories, respectively.

Tables IIIa and IIIb give the outcomes of productivity indices, and demand probabilities from the application of the new model to the selected enterprises.

Tables IVa and Va give the sensitivity outcomes of the new model when subjected to the probability of increased funding on the selected factories. Similarly, productivity index results due to change in demand in the respective enterprises are presented in Tables IVb and Vb, respectively. It can be deduced from the results in Tables IVa that productivity increase rate due to increased funding is very slow. This indicates that productivity index is weakly sensitive to increased funding in the vegetable oil business.

Productivity index due to demand change was slower (Table IVb). This indicates that the low funding level is optimal for the existing demands.

However, in sachet water factory, there was appreciable improvement in the productivity index as a result of increased funding (Table Va). This is an indication that sachet water productivity is more sensitive to increased funding than the vegetable oil factory. This can be supported by the sensitivity results in the table in which appreciable productivity was achieved in a short-term plan of 5 years at 30 % funding increase and above. In the premise of demand rate, the productivity required is less than the one obtained from the factory (Table Vb). This shows that the funding capability, though low, was adequate for the demand.

TABLE I
VEGETABLE OIL PRODUCTIVITY INDEX (Q_{DT}) USING TRADITIONAL APPROACH

Day	$Q_t(tonn$	$L_t(tonn$	$Q_o(tonne)$	$L_o(tonne)$	
Monday	40	15	4	2	0.33
Tuesday	36	15	5	1	0.48
Wednesday	38	15	6	3	0.14
Thursday	35	15	3	1.5	0.52
Friday	40	15	2	3	0.44
Average	37.8	15	4	2.1	0.27

TABLE II
SACHET WATER PRODUCTIVITY INDEX (Q_{DT}) USING TRADITIONAL APPROACH

Day	$Q_t(tonn$	$L_t(tonn$	$Q_o(tonne)$	$L_o(tonne)$	
Monday	20	20.02	2	1.0	0.526
Tuesday	19	20.02	1.5	1.5	0.456
Wednesday	18	20.02	3	2.0	0.166
Thursday	19	20.02	4	1.3	0.195
Friday	17	20.02	1.0	1.2	0.753
Average	18.6	20.02	2.3	1.4	0.419

TABLE IIIA
PRODUCTIVITY INDEX (Q_{PT}) WITH THE DEVELOPED MODEL (SACHET WATER AND VEGETABLE OIL FACTORIES)

Days	Sachet Water Factory			Vegetable Oil Factory		
	Q_{dt}	$P(t)$	Q_{pt}	Q_{dt}	$P(t)$	Q_{pt}
1	0.526	0.428	0.225	0.33	0.428	0.141
2	0.456	0.333	0.152	0.48	0.333	0.160
3	0.166	0.428	0.071	0.14	0.428	0.060
4	0.195	0.333	0.065	0.52	0.333	0.172
5	0.753	0.428	0.316	0.44	0.428	0.188
Mean	0.419	0.39	0.1658	0.27	0.39	zc0.144

TABLE IIIB
PROBABILITY OF DEMANDS IN THE SACHET WATER AND VEGETABLE OIL FACTORIES

Days	Sachet water factory			Vegetable oil factory		
	Demand Q_t - Q_o	Demand Q_t - Q_o	Demand Q_t - Q_o	Demand Q_t - Q_o	$P(t)$	Q_{pt}
1	18	36	36	36	0.428	0.141
2	17.5	31	31	31	0.333	0.160
3	15	32	32	32	0.428	0.060
4	15	32	32	32	0.333	0.172
5	16	38	38	38	0.428	0.188
Mean	μ=16.3	μ=33.8	μ=33.8	μ=33.8	0.39	0.144

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TABLE IVA
CHANGE IN PRODUCTIVITY INDEX (Q^{T}_{PT}) WITH INCREASED FUNDING, P(T') (VEGETABLE OIL FACTORY)

***P*(*t*)', Yrs, T**	**0**	**1**	**2**	**3**	**4**	**5**
1%	0.105	0.106	0.107	0.108	0.109	0.111
5%	0.105	0.110	0.116	0.122	0.128	0.134
10%	0.105	0.115	0.127	0.140	0.154	0.170
20%	0.105	0.126	0.152	0.182	0.218	0.262
30%	0.105	0.137	0.178	0.231	0.300	0.391
40%	0.105	0.147	0.206	0.289	0.404	0.566
50%	0.105	0.158	0.237	0.355	0.533	0.800

TABLE IVB
CHANGE IN PRODUCTIVITY INDEX (Q^{T}_{PT}) WITH INCREASED DEMAND, P(Q') (VEGETABLE OIL FACTORY)

P(Q'), T	**0**	**1**	**2**	**3**	**4**	**5**
1%	0.0729	0.0799	0.0876	0.0960	0.1053	0.1154
5%	0.0729	0.0801	0.0881	0.0968	0.1064	0.1169
10%	0.0729	0.0805	0.0881	0.0983	0.1086	0.1199
20%	0.0729	0.0812	0.0905	0.1008	0.1123	0.1251
30%	0.0729	0.0819	0.0921	0.1035	0.1164	0.1308
40%	0.0729	0.0826	0.0936	0.1060	0.1201	0.1361
50%	0.0729	0.0833	0.0952	0.1089	0.1244	0.1422

TABLE VA
CHANGE IN PRODUCTIVITY INDEX (Q^{T}_{PT}) WITH INCREASED FUNDING, P(T') (SACHET WATER FACTORY)

***P*(*t*)', Yrs, T**	**0**	**1**	**2**	**3**	**4**	**5**
1%	0.163	0.165	0.167	0.1482	0.1700	0.172
5%	0.163	0.171	0.180	0.190	0.199	0.208
10%	0.163	0.179	0.180	0.217	0.24	0.263
20%	0.163	0.196	0.235	0.282	0.338	0.407
30%	0.163	0.212	0.276	0.359	0.467	0.606
40%	0.163	0.230	0.320	0.450	0.630	0.880
50%	0.163	0.245	0.37	0.55	0.83	1.241

TABLE VB
CHANGE IN PRODUCTIVITY INDEX (Q^{T}_{PT}) WITH INCREASED DEMAND, P(Q') (SACHET WATER FACTORY)

P(Q'),Yrs, T	**0**	**1**	**2**	**3**	**4**	**5**
1%	0.113	0.136	0.163	0.195	0.234	0.281
5%	0.113	0.137	0.166	0.201	0.244	0.296
10%	0.113	0.138	0.168	0.205	0.250	0.305
20%	0.113	0.140	0.174	0.215	0.267	0.331
30%	0.113	0.142	0.179	0.226	0.285	0.359
40%	0.113	0.145	0.185	0.237	0.303	0.388
50%	0.113	0.147	0.191	0.248	0.323	0.420

IV. CONCLUSION

Many Small and Medium Enterprises (SMEs) are not aware of importance of demand in determining the level of desired productivity. Instead, more funding are agitated for which may not add any value to the existing productivity in the SMEs. The study showed that there was a significant relationship between funding and demand as far as productivity of SMEs is concerned. Gradual increase in funding will improve productivity of the SMEs but this improvement would not have any meaning after demands are satisfied. Funding as one of the key ingredients that affects productivity is limited; hence, the need for a decision support system to help in determining funding alternatives is paramount for demands sustainability. The new system relaxed the rigidity of the traditional productivity system and established threshold values for funding and productivity. The new system was robust and flexible in evaluating the productivity performance indices of the enterprises at different probability of funding and demand levels. The productivities of the SMEs were low based on the level of funding but they are sustainable for the levels of services rendered by the enterprises. The findings showed that the funding level of the SMEs was adequate enough to take care of the demanded products. This indicated the prominent role played by the volume of demands in determining the optimal productivity and funding levels to operate in the SMEs.

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