

SUPPLEMENTARY MATERIAL

Mathematical Model for the Control of Unemployment in Nigeria Incorporating Vocational Education and Apprenticeship

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Appendix A: Estimation of Variables and Parameters

V1: The Total Working-age Population, N

According to the National Bureau of Statistics report for third quarter (Q3) 2023, labour force participation rate is 79.5% (See Appendix B, Table 4) and the total labour force in Nigeria for 2023 was estimated to be 75,721,345 (Trading Economics). Therefore,

$$\text{Labour Force Participation rate} = \frac{\text{Total Labour Force (LF)}}{\text{Total Working-age population (N)}}$$

$$N = \frac{\text{Total Labour Force (LF)}}{\text{Labour Force Participation rate}}$$

$$N = \frac{75,721,345}{0.795}$$

$$N \approx 95,246,975$$

V2: Total Employment, E

According to the National Bureau of Statistics report for Q3 2023, employment-to-population ratio is 75.6% (See Appendix, Table 4). Therefore,

$$\text{Employment - to - Population ratio} = \frac{\text{Total Employment (E)}}{\text{Total Working-age population (N)}}$$

$$E = \text{Employment - to - Population ratio} \times \text{Total Working-age population (N)}$$

$$E = 0.756 \times 95,246,975$$

$$E \approx 72,006,713$$

V3: Number of Apprenticed, A

The Total unemployment, U_T is the sum of unemployed individuals and people in apprenticeship programs. According to the National Bureau of Statistics (NBS) report for Q3 2023, unemployment rate was 5.0% (See Appendix B, Table 4). Therefore,

$$U_T = \text{unemployment rate} \times \text{Total Labour Force}$$

$$U_T = 0.005 \times 75,721,345 \approx 3,786,067$$

Assuming 20% of individual in U_T , during their unemployment waiting period are apprentices. Implies,

$$A = 20\% \text{ of } U_T = 0.20 \times 3,786,067$$

$$A \approx 757,213$$

V4: Number of Unemployed, U

From V3 above,

$$\text{Number of unemployed } (U) = U_T - A$$

$$U = 3,786,067 - 757,213$$

$$U = 3,028,854$$

V5: Total Number of Recruitment, Λ

According to the National Bureau of Statistics (NBS) report for Q3 2023, percentage of potential labour force is 20.5% (See Appendix B, Table 4). Therefore,

$$\text{Potential Labour Force } (\Lambda) = 20.5\% \text{ of Total working - age population}$$

$$\Lambda = 0.205 \times 95,246,975$$

$$\Lambda \approx 19,525,630$$

V6: Number of Highly-skilled Individuals, H_s

The Total Vocational individuals, V_T is the sum of highly-skilled graduates from Technical Vocational and Training (TVET) and people currently in Vocational programs. Assuming TVET individuals accounts for about 20% of the total potential labour force population. Therefore,

$$\phi = 0.20$$

Implies,

Total Vocational Individuals, $V_T = 20\%$ of Potential Labour Force

$$V_T = 3,905,126$$

Insight from Digest Statistics of TVET shows that about 30% of VTET students graduate every year while 40% of them are expected to be highly-skilled, [1].

$$\text{Number of VTET graduate} = 30\% \text{ of } V_T \approx 1,171,538$$

Thus,

$$\text{Number of Highly-skilled } H_s = 40\% \text{ of } 1,171,538$$

$$H_s \approx 468,615$$

V7: Number of Vocational Individuals, V

From V6 above,

$$\text{Number of Vocation individuals } (V) = V_T - H_s$$

$$V = 3,905,126 - 468,615$$

$$V = 3,436,511$$

V8: Number of Individual in Theoretical Education, T

Recall:

$$N = V + T + U + H_s + A + E$$

Therefore,

$$T = N - (V + U + H_s + A + E)$$

$$T = 95,246,975 - (3,436,511 + 3,028,854 + 468,615 + 757,213 + 72,006,713)$$

$$T = 95,246,975 - 79,697,906$$

$$T = 15,549,069$$

P1: Rate of Withdrawal, μ

According to the National Bureau of Statistics (NBS) report for Q3 2023, 3.1% of potential labour force are discourage jobseekers ((See Appendix B). Other set of people who have exited

the labor force includes; Retirees, emigrants, deceased and others who have left the labor market for various reasons such as illness or disability, caregivers etc. Therefore,

$$\text{Estimated number of withdrawal } (W) = 3.1\% \text{ of } \Lambda + (E + U_T - LF)$$

$$W = (0.031 \times 19,525,630) + (72,006,713 + 3,786,067 - 75,721,345)$$

$$W = 605,294 + 71,434 = 676,728$$

Thus,

$$\text{Withdrawal } \mu = \frac{\text{Estimated number of withdrawal } (W)}{\text{Total working-age population } (N)}$$

$$\mu \approx \frac{676,728}{95,246,975}$$

$$\mu \approx 0.0071$$

P2: Tendency of Becoming Unemployed, δ

The Tendency of becoming unemployed was defined as

$$\delta = \psi\theta(1 - \rho)$$

Where,

ψ is the per capita probability of becoming unemployed

θ is the rate of influence of unemployed on people in theoretical education, and

ρ is the Vocation program successful implementation rate

$$\psi = \frac{\text{Unemployment rate } (UR) \times \text{Labour Force } (LF)}{\text{Total working - age population } (N)}$$

$$\psi = \frac{0.05 \times 75,721,345}{95,246,975} \approx 0.040$$

Assume a correlation coefficient (r) of 0.5 between unemployed class and influence on theoretical class,

$$\theta = r \times UR = 0.5 \times 0.05 = 0.025$$

Assume a success rate (SR) of 15% for vocation programs.

$$\rho = SR \times (1 - UR) = 0.15 \times (1 - 0.05) \approx 0.14$$

Thus,

The Tendency of becoming unemployed is

$$\delta = \psi\theta(1 - \rho)$$

$$\delta = (0.040 \times 0.025)(1 - 0.1425) \approx 0.00086$$

P3: Tendency of Becoming Employed by Apprenticeship, δ

The Tendency of unemployed becoming employed due apprenticeship to was defined as

$$\varepsilon = \omega\tau(1 - \sigma)$$

Where,

ω is the per capita probability of becoming employed

τ is the rate of influence of apprenticed on the unemployed, and

σ is the apprenticeship program successful implementation rate

$$\omega = \frac{\text{employment rate } (ER) \times \text{Labour Force } (LF)}{\text{Total working-age Population } (N)}$$

$$\omega = \frac{0.756 \times 75,721,345}{95,246,975} \approx 0.60$$

Assume a correlation coefficient (r) of 0.8 between apprenticeship class and employment class,

$$\tau = r \times ER = 0.8 \times 0.756 \approx 0.61$$

Assume a success rate (SR) of 85% for apprenticeship programs

$$\sigma = SR \times (1 - ER) = 0.85 \times (1 - 0.756) \approx 0.21$$

Thus,

The Tendency of becoming employed by apprenticeship is

$$\varepsilon = \omega\tau(1 - \sigma)$$

$$\varepsilon = (0.60 \times 0.6048)(1 - 0.2074) \approx 0.28914$$

P4: Theoretical Education Graduate Employment Rate, γ

Each academic year, universities and polytechnics admit close to 2 million students and produce about 600,000 graduates (University World News). According to the NBS (2020),

about 60% of Nigerian graduates find employment within the first year after graduation. Therefore,

$$\gamma = 0.60$$

P5: Highly-skilled Vocational Graduate Employment Rate, α

Based on industry trends and National Labour Force Statistic report for Q4, 2020 (NBS 2020), VTET graduation-to-highly-skilled employment rate is approximately 0.90. Therefore,

$$\alpha = 0.90$$

P6: Rate of Transition of Becoming Employed due to Apprenticeship, b

Based on industry trends and National Labour Force Statistic report for Q4, 2020 (NBS 2020), apprenticeship-to-employment rate is approximately 0.85. Therefore,

$$b = 0.85$$

Rate of Investment, η

Based on historical trends and industry reports, the investment rate in highly-skilled and apprenticed labor for 2023 was assumed to be 0.12. Therefore,

$$\eta = 0.12$$

Appendix B

Table 4: Labour Market Indicators by Sex and Place of Residence [2]

Headline labour market indicators and main aggregates	Age 15 plus			URBAN			RURAL		
	TOTAL	SEX		TOTAL	SEX		TOTAL	SEX	
		M	F		M	F		M	F
Labour force population	79.5	80.9	78.2	75.6	77.1	74.2	84.1	85.2	83.0
Employed population	75.6	77.7	73.5	71.1	73.3	69.1	80.7	82.7	78.7
Unemployed population	5.0	4.0	6.0	6.0	5.0	6.9	4.0	2.9	5.1
Outside the labour force population	20.5	19.1	21.8	24.4	22.9	25.8	15.9	14.8	17.0
Time-related underemployment	12.3	8.7	16.0	11.3	9.2	13.5	13.3	8.1	18.6
Discouraged job-seekers	3.1	3.7	2.6	2.1	2.7	1.6	4.8	5.3	4.4
Self-employed	87.3	84.2	90.5	80.3	76.2	84.4	94.5	92.2	96.9
Employees	12.7	15.8	9.5	19.7	23.8	15.6	5.5	7.8	3.1
Employed population in agriculture	33.6	43.6	23.4	17.5	22.2	12.7	50.0	65.4	34.3
Informal employment	92.3	88.7	96.0	87.5	81.9	93.1	97.2	95.5	98.9
Informal employment (excluding agriculture)	88.7	80.4	94.9	85.1	77.2	92.3	94.7	87.8	98.4
Young labour force (aged 15-24)	60.3	59.8	60.8	49.8	49.8	49.8	72.6	71.7	73.5
Young employed (aged 15-24)	55.1	54.9	55.3	44.5	44.7	44.3	67.5	67.0	68.1
Young unemployed (aged 15-24)	8.6	8.3	9.0	10.7	10.3	11.1	7.0	6.6	7.4
NEET (aged 15-24)	13.7	12.0	15.5	14.2	14.0	14.5	13.1	9.6	16.6
Own-use producers of foodstuffs	4.1	5.5	2.7	2.5	3.1	1.9	6.0	8.3	3.6
LU2	16.7	12.3	21.1	16.6	13.7	19.5	16.8	10.9	22.7
LU3	7.1	6.0	8.2	7.7	6.8	8.6	6.4	5.2	7.7
LU4	18.5	14.1	22.9	18.1	15.3	20.9	18.9	12.9	24.9

Appendix C

Table 5: Labour Force Statistics, Q4, 2020 [3]

	LABOUR FORCE POPULATION	Work 40 Hrs+	Work 20 -39 Hrs	Work 1 -19 Hrs	Work 0 Hr (Did nothing)	Total Employed	Total Unemployed
		Fully Employed	Under- employed	Unemployed	Unemployed		
Total	69,675,468	30,572,440	15,915,639	11,027,211	12,160,178	46,488,079	23,187,389
Educational						-	
None	20,652,597	8,414,119	6,378,368	3,839,639	2,020,472	14,792,487	5,860,110
First School Leaving Certificate	9,240,842	4,191,875	2,197,042	1,642,647	1,209,280	6,388,916	2,851,926
Middle School Leaving Certificate	326,025	162,474	82,671	49,129	31,750	245,145	80,880
Vocational/Commercial	233,535	96,993	66,592	46,598	23,352	163,585	69,950
Junior Secondary School Certificate	3,351,293	1,477,931	719,264	529,298	624,799	2,197,195	1,154,097
Senior Secondary School Certificate	22,031,170	9,686,538	4,165,532	3,140,116	5,038,984	13,852,070	8,179,100
A' levels	748,228	272,915	95,978	169,570	209,766	368,892	379,336
NCE/OND/Nursing	5,779,243	2,766,061	1,163,199	679,592	1,170,392	3,929,259	1,849,984
BA/BSc/HND	5,940,546	2,817,286	741,208	672,334	1,709,718	3,558,494	2,382,052
Tech/Prof	187,033	82,660	51,537	25,075	27,760	134,198	52,835
Masters	349,306	189,592	62,518	56,748	40,448	252,110	97,196
Doctorate	73,859	46,054	15,323	12,483	-	61,377	12,483
others (specify)	761,792	367,942	176,408	163,985	53,456	544,351	217,441

REFERENCES

- [1] N. NBTE, “2018 -2019 Digest of TVET Institutions Statistics in Nigeria,” National Board for Technical Education, Kaduna, Nigeria, Rep., 2019.
- [2] N. NBS, “Nigeria Labour Force Survey Report,” National Bureau of Statistics, Abuja, Nigeria, Rep., Q3 2023.
- [3] N. NBS, “Labour Force Statistics: Unemployment and Underemployment Report,” National Bureau of Statistics, Abuja, Nigeria, Rep., Q4 2020.