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# Women in Science, Technology, Engineering and Mathematics Towards Economic Growth in Nigeria

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## Abstract
This paper investigated the contributions of women in Science, Technology, Engineering and Mathematics (STEM) towards economic growth in Nigeria by considering the proportion of female employed in the labour force relative to male. Annual data from 1990-2019 on female labour force participation rate, male labour force participation rate and total labour force participation rate in the country were collated. Real gross domestic product was employed as a proxy for growth. The existence of cointegration was established between RGDP and the control variables and on this basis, the long and short-term autoregressive distributed lag (ARDL) model was estimated. The results revealed directly significant relation between female labour force participation rate and real gross domestic product, male labour force participation rate and real gross domestic product and an inversely significant relationship between total labour force participation and real gross domestic product in the short-term. The signs of the estimates remain constant in the long-term. However, the magnitude revealed an opposing result between real gross domestic product and the labour force participation rates in the steady state. The findings led to the conclusion that the economy should focus on scholarship opportunities for female students in STEM in the present period and long-term and continuous investment in the girl-child participation in STEM to spur economic growth in the country.
**Keywords:** Labour Force Participation Rate, RGDP, STEM, ARDL

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## 1. Introduction
This paper seeks to consider the vast opportunities that abound to any economy in terms of increase in output as a result of having more women in STEM relative to men translating into increase in female labour force participation relative to male by adopting a pragmatic approach. Ceci, Williams and Bernett (2009) and Griffith (2010) viewed Women in science, technology, engineering and mathematics (STEM) as female in "well-compensated, high-status professions with universal career appeal". Women in STEM is thought of having significant impact on a number of policies targeted at accelerating the pace of productivity, inclusive growth and sustainable development in all economies. Dee (2007) opines that reduction in the number of females in STEM fields is attributable to stereotypes and educational differences with the girl-child improving in reading while the boys improve in mathematics from the lower/ primary educational level. It was asserted that the rising female employment captured by the rising female labor force participation rates in the rich countries has been a major driving force behind global gross domestic product in the last two decades at the world economy level. The stimulating impact of rising female labor force participation

has been found widely in India and China; the states growing the fastest, reducing poverty and child mortality the most are those with the highest percentage of women in the labor force (Blumberg, 2002).

There are numerous studies on employment, fertility rates and productivity of women in STEM, for examples: Heckman (1978) and Standing (1981). Also, a number of theoretical and empirical works in the literature revealed that female labor force participation exerts a direct, female as a role model, strong and beneficial relations with economic growth, (Tansel, 2002; Fatima & Sultana, 2009). On societal and women representation, quantitative abilities: Warren, (2018), Ellis *et al* (2016), Ceci *et al* (2014), Kelly (2013), Miyake et al. (2010), Griffith (2010); Stout *et al* (2011) Cheryan *et al*.,( 2011), Taylor and Hosch, (2004), Ellemers *et al.* (2004), Schiebinger (1999), and Cooper (1997). Other studies that robustly investigated the issue include: Barbara *et al* (2017), Page (2015), Su *et al*. (2009), Lips (2008), Johnson (2007), Keller *et al*. (2001) and Pell (1996). Steinberg (2012) purports that besides lack of confidence barring women from entering STEM fields. Refer also to: Miller, (2015), Williams (1992), Bork (2012), Schmader and Johns (2003), Steele *et al*. (2002), Spencer *et al (*1999), Steele *et al* (1995). To encourage women participation in STEM and digital skills among others: Ogundipe (2017), Okello (2017), Sonnert *et al* (2007), Griffith (2010), Stout *et al* (2011), Johns *et al* (2005) and Marx and Roman (2002). Other researches on stylized facts, child mortality, and women performance include: Women and Girls in Science (2017), Stearns (2016), Women's Right Online (2015), Gresky *et al* (2005), Johns *et al* (2005), Martens *et al* (2006), Marx and Roman (2002) and Mclntyre *et al* (2003). Despite bulk of researches which had been conducted in the area, it appears there are lower employment opportunities to female in STEM, consequently; this paper examined the contributions of women in STEM towards growth and real productivity in the economy.

## 2. Methodology

To investigate the relationship between economic growth and women in STEM, annual data on female labour force participation rate and Real Gross Domestic Product; RGDP were employed. Data on male labour force participation rate as well as total labour force participation rate were also included in the analysis. The labour force is defined as the number of individuals who are employed and those that are unemployed but available, willing to work and have scouted for a job recently but could not get employed. The seminal contribution of Dogan and Akyuz (2017) was employed in this study and data was sourced from the World Development Indicators; WDI and modeled International Labour Organisation (ILO) statistics. Female labour force participation rate is given as percentage of female population ages 15-64. Male labour force participation as percentage of male population ages15-64 and total labour force participation as percentage of total population ages 15-64. The series were examined to determine whether their mean and variance are constant and confirm that the covariance of the series depends on the lead or lag series and not on time. Real gross domestic product (RGDP) was employed as a proxy for economic growth as it allows for the distortion of fluctuating prices on intertemporal total output. The ARDL bound test was employed as it allows for estimation of series of I(0) and I(1) series. The bounds test was also conducted to determine the existence of relationship amongst the variables in the model in the steady state. The ARDL (p, q) model includes the lagged values of the regressand as well as the current and lagged values of the regressors as explanatory variables in the equation to be estimated. In this case, the model is specified as ARDL(p,q,r,s). The short run model specification is differentiated from the long run model specification with the difference operator symbol; Δ. The base-line model employed for this work is specified as:

$$LOG(RGDP_t) = \delta_0 + \delta_1 LOG(FLFP) + \delta_2 LOG(MLFP) + \delta_3 LOG(TLFP) + \varepsilon_t \quad (1)$$

Following the work of Pesaran et al. (2001), the long run model specification is given as:

$$LOG(RGDP_t) = \lambda_0 + \lambda_1 LOG(RGDP_{t-i}) + \lambda_2 LOG(FLFP_{t-i}) + \lambda_3 LOG(MLFP_{t-i}) + \lambda_4 LOG(TLFP_{t-i}) + \varepsilon_t ........(2)$$

The Unrestricted Error Correction Model (UECM)/Auto-Regressive Distributed Lag model; ARDL(p,q,r,s) is specified as follows:

$$\Delta LOG(RGDP_t) = \gamma_0 + \sum_{i=1}^{p} \gamma_i \Delta LOG(RGDP_{t-i}) + \sum_{j=0}^{q} \gamma_j \Delta LOG(FLFP_{t-j}) + \sum_{k=0}^{r} \gamma_k \Delta LOG(MLFP_{t-k}) + \sum_{l=0}^{s} \gamma_l \Delta$$
$$LOG(TLFP_{t-l}) + \mu_i LOG(RGDP_{t-i}) + \mu_j LOG(FLFP_{t-j}) + \mu_k LOG(MLFP_{t-k}) + \mu_l LOG(TLFP_{t-l}) + \varepsilon_t ..........(3)$$

$$i = 1,......, p;\ j = 0,......., q; k = 0,......, r; l = 0,......s$$

Further, the Error correction model adapted for this study is given below;

$$\Delta LOG(RGDP_t) = \varphi_0 + \sum_{i=1}^{V_1} \varphi_i \Delta LOG(RGDP_{t-i}) + \sum_{j=0}^{V_2} \varphi_j \Delta LOG(FLFP_{t-j}) + \sum_{k=0}^{V_3} \varphi_k \Delta LOG(MLFP_{t-k}) +$$
$$\sum_{l=0}^{V_4} \varphi_l \Delta LOG(TLFP_{t-l}) + \lambda ECT_{t-1} + e_t ..........................................................................................(4)$$

$$i = 1,......, V_1;\ j = 0,......., V_2; k = 0,......, V_3; l = 0,......V_4$$

Where $RGDP_t$, $FLFP$, $MLFP$, $TLFP$ denote Real Gross Domestic Product at period t, Female labour force participation rate, Male labour force participation rate and Total labour force participation rate respectively. $\delta_0$ depicts the model intercept or constant term, $\delta_1, \delta_2, \delta_2$ depict the slope terms; coefficients of FLFP, MLFP and TLFP respectively, Δ depicts the difference operator in the short run , λ represents the coefficient of the error correction term and depicts the speed of adjustment. The error correction term; ECT captures the steady state relationship in the model. $\varepsilon_t$ represents the stochastic error term.For the short run equation, long run equation and error correction model, $\pi_0$, $\gamma_0$ and $\varphi_0$ are the constant terms respectively.

## 3. Empirical Analysis and Discussion of Results

### 3.1 Data Issues and Preliminary Analysis

The study employed data from the World Bank's World Development Indicators for the period 1990 to 2019. The group statistical features of the series adopting the standard procedures for variables with time series properties was embarked upon from conducting the descriptive statistics presented below:

**Table 1: Descriptive Statistics of Variables**

| | LOG(RGDP) | LOG(FLFP) | LOG(MLFP) | LOG(TLFP) |
|---|---|---|---|---|
| **Mean** | 31.26333 | 3.983334 | 4.152167 | 4.071829 |
| **Median** | 31.25765 | 4.012456 | 4.166634 | 4.093519 |
| **Maximum** | 31.90899 | 4.014471 | 4.204469 | 4.114131 |
| **Minimum** | 30.70742 | 3.879149 | 4.073410 | 3.981941 |
| **Std. Dev.** | 0.461152 | 0.051949 | 0.041722 | 0.045655 |

| | | | | |
|---|---|---|---|---|
| **Skewness** | 0.111360 | -1.229226 | -0.886646 | -1.141028 |
| **Kurtosis** | 1.399239 | 2.633600 | 2.368800 | 2.532149 |
| **Jarque-Bera** | 3.265052 | 7.722791 | 4.428725 | 6.783327 |
| **Probability** | 0.195435 | 0.021039 | 0.109223 | 0.033653 |
| **Sum** | 937.9000 | 119.5000 | 124.5650 | 122.1549 |
| **Sum Sq. Dev.** | 6.167181 | 0.078264 | 0.050480 | 0.060447 |
| **Observations** | 30 | 30 | 30 | 30 |

**Note:** LOG(FLFP), LOG(MLFP), LOG(TLFP), LOG(RGDP) represent log of female labour force participation rate, log of male labour force participation rate, log of total labour force participation rate, log of real gross domestic product.

Real gross domestic product was employed instead of nominal gross domestic product to allow for the impact of inflation on intertemporal output. The female labour force participation rate is given as the percentage of female population ages 15-64, male labour force participation rate as the percentage of male population ages 15-64 and total labour force participation rate as the percentage of the total population ages 15-64. The total labour force participation is the total number of people who are available or willing to work or have looked for a job recently as a percentage of the total population.

### 3.2 Unit Root Test Results

**Table 2: Unit Root (Stationarity) Test.**

| **Variable** | **Augmented Dickey-Fuller (ADF ) Test Statistics** | | **Phillips Perron (PP) Test Statistics** | | **Dickey-Fuller GLS Test Statistics** | |
|---|---|---|---|---|---|---|
| | **Level** | **First Difference** | **Level** | **First Difference** | **Level** | **First Difference** |
| **LOG(RGDP)** | -0.5004(1) | -2.6691(0)* | 0.0798(3) | -2.6259(4)* | -0.4211(1) | -2.4715(0)** |
| **LOG(FLFP)** | -0.4569(1) | -2.7864(0)* | 0.2712(2) | -2.9117(1)* | -0.6169(1) | -2.8245(0)*** |
| **LOG(MLFP)** | -0.5344(1) | -3.2517(0)** | 0.0189(1) | -3.2181(2)** | -0.4186(1) | -3.2896(0)*** |
| **LOG(TLFP)** | -0.4401(1) | -3.0110(0)** | 0.2770(1) | -2.9895(2)** | -0.4995(1) | -3.0497(0)*** |
| **Sig. level:1%** | -3.689 | -3.689 | -3.679 | -3.689 | -2.650 | -2.650 |
| **5%** | -2.972 | -2.972 | -2.968 | -2.972 | -1.953 | -1.953 |
| **10%** | -2.625 | -2.625 | -2.623 | -2.625 | -1.610 | -1.610 |

Note: The values presented in parenthesis in the ADF and DF-GLS tests are the selected delay lengths using the Schwarz Information Criterion (SIC) when the maximum delay length is 7. Newey-West Bandwith (Automatic Selection) criteria using Bartlett Kernel (default) spectral estimation method was employed in the PP test. ***, **, * denote statistical significance at 1%, 5% and 10% levels respectively.

Following the results of the ADF, PP and DF-GLS tests, all the variables employed in the model are differenced stationary processes, I(1).

### 3.3 Cointegration Test

The ARDL-bounds test approach to cointegration gives room for flexibility as it can be applicable irrespective of whether variables employed in the model are I(0), I(1) or combination of both (Pesaran et al., 2001). The outcome of the ARDL-bounds test conducted to determine the existence or otherwise of long-term relationship amongst the variables employed in the model is presented below:

**Table 3: Bounds test result**

| Test Statistic | Value | Sig. | I(0) | I(1) |
|---|---|---|---|---|
| F-statistic | 6.350104 | 1% | 4.29 | 5.61 |
| k | 3 | 2.5% | 3.69 | 4.89 |
| | | 5% | 3.23 | 4.35 |
| | | 10% | 2.72 | 3.77 |

The bounds test adopted for the test of cointegration is specified as follows:

$$H_0 : \mu_{1,Z} = 0$$
$$H_1 : \mu_{1,Z} \neq 0$$
$$z = i, j, k, l.$$

The computed F-bounds test value of 6.35 exceeds the 1% critical value at the upper bound levels {I(1): (5.61). We, therefore, reject $H_0$ and conclude that there exists a steady state relationship among the variables in the model.

**Table 4: The Vector Auto Regression Analysis: Detection of Delay Length for Bound Test**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 21.14367 | NA | 0.014897 | -1.371494 | -1.176474 | -1.317403 |
| 1 | 60.81588 | 63.47553 | 0.000677 | -4.465270 | -4.221495* | -4.397657 |
| 2 | 61.07318 | 0.391104 | 0.000721 | -4.405854 | -4.113324 | -4.324719 |
| 3 | 61.21081 | 0.198186 | 0.000778 | -4.336865 | -3.995580 | -4.242207 |
| 4 | 65.40121 | 5.698943* | 0.000607* | -4.592097* | -4.202057 | -4.483916* |
| 5 | 66.09444 | 0.887335 | 0.000629 | -4.567555 | -4.128760 | -4.445852 |

Note: * indicates lag order selected by the criterion, LR, FPE, AIC, SC, HQ indicate sequential modified LR test statistic (each at 5% level), final prediction error, Akaike information criterion, Schwarz information criterion, Hannan-Quinn information criterion respectively. The Schwarz Information Criteria (SIC) is adopted in determining the delay length for the Bound test given that its optimal delay length is 1 when the maximum delay length is 6. There is therefore no auto correlation as SIC takes the minimum value.

**Table 5: ARDL (1,1,1,1) Model Estimated Results**

| **Long-term coefficients** | | **Long-term Levels Coefficient** | |
|---|---|---|---|
| **Variable** | **Coefficient** | **Variable** | **Coefficient** |
| **LOG(RGDP(-1))** | 0.9978 | **LOG(FLFP)** | -1603.801 |
| | (0.0553)*** | | (2367.932) |
| **LOG(FLFP(-1))** | 5.3664 | **LOG(MLFP)** | -2030.105 |
| | (72.1982) | | (3094.515) |
| **LOG(MLFP(-1))** | 2.1490 | **LOG(TLFP)** | 3639.862 |
| | (84.8787) | | (5470.231) |
| **LOG(TLFP(-1))** | -7.8148 | **C** | 0.0062 |
| | (157.5158) | | (0.0116) |
| **C** | 1.6291 | | |
| | (1.8580) | | |
| **Diagnostic test** | | | |
| $R^2$ **= 0.997** | **BG(LM) Test=0.1766(0.6782)** | **BPG(Hetero.) Test=0.6788(0.5733)** | **F-statistics = 2137.127(0.0000)** |
| $\bar{R}^2$ **= 0.996** | **RR=0.56(0.5756)** | **JB=13.5572(0.0011)** | **DW = 1.82** |
| **Short-term Coefficients** | | | |
| **Variable** | | **Coefficient** | |
| ΔLOG(RGDP(-1)) | | 1.0841 | |
| | | (0.1891)*** | |
| ΔLOG(FLFP(-1)) | | 205.3006 | |
| | | (109.54)* | |
| ΔLOG(MLFP(-1)) | | 243.4902 | |
| | | (130.99)* | |
| ΔLOG(TLFP(-1)) | | -449.3751 | |

| | | | |
|---|---|---|---|
| | | (240.61)* | |
| **ECT** | | -0.9607 | |
| | | (0.2672)*** | |
| **Diagnostic tests** | | | |
| $R^2$ **= 0.632** | **BG(LM) Test=0.3481(0.5615)** | **BPG(Hetero.) Test=0.2701(0.9246)** | **F-statistics= 7.5557(0.0003)** |
| $\bar{R}^2$ **= 0.548** | **RR=0.0012(0.9728)** | **JB=18.6229(0.0001)** | **DW = 1.75** |

Note: FLFP, MLFP, TLFP, RGDP represent female labour force participation rate, male labour force participation rate, total labour force participation rate, real gross domestic product. Δ indicate the difference operator for the short run analysis, (-1) denotes that the variables are lagged one period, LOG indicates that the variables are in the log form. Standard errors are given in parentheses. For the F-statistics, Ramsey Reset(RR), Breusch-Godfrey Serial Correlation (BG) LM test, Breusch-Pagan-Godfrey (BPG) Heteroscedasticity test, Jarque-Bera (JB) normality test, the p-values are given in the parentheses.

### 3.4 Empirical Results

The empirical analysis focuses on the ARDL model employed for this study. The results from the ADF, DF-GLS and PP unit root tests revealed that all the series are differenced stationary processes. The F-statistics from the Unrestricted Error Correction Mechanism (UECM) indicates that there is level relationship among the series in the steady state given that the calculated F exceeds the upper bound at 1 percent conventional level. The lag length selection based on the different criteria when the maximum delay length is 5 shows the Schwarz Information Criteria (SIC) taking the minimum value and indicating no autocorrelation. In the short-term, a percentage change in RGDP will result to about 1.08 percentage points increase in one period lagged RGDP coefficient. The result revealed a directly significant relationship between the log of RGDP and its one period lagged value at the 1% conventional level, a directly significant relationship between the log of RGDP and one period lagged value of the log of FLFP and one period lagged value of the log of MLFP at the 10% conventional level respectively while the log of RGDP and one period lagged value of TLFP remains significantly negative at the 10% conventional level. A unit increase in FLFP and MLFP will spur RGDP by about 205 and 243 points on the average respectively while a unit increase in TLFP will generate a deteriorating impact on RGDP coefficient of about 449 points in the RGDP coefficient. In the long-term, the relationship between the log of RGDP and FLFP as well as the log of RGDP and MLFP remain positive but insignificant while that of the log of RGDP and TLFP remains negative and insignificant in the long. A unit increase in FLFP and MLFP will result into 5.366 and 2.149 points increase in RGDP, while that of TLFP will lead to a 7.815 points reduction in RGDPThe establishment of cointegration ascertaining the validity of the steady state estimates resulted into analysing the short-term dynamics and estimating the error correction model. The short-term analysis is established adopting a test based on the speed of adjustment or error correction concept. The long run model was estimated and the residuals generated from the estimation output was introduced as the error correction term; ECT in the error correction model. The ECT details the speed of adjustment and its negative value ensures that the system is reverted to equilibrium in the event of divergence. A significant negative coefficient obtained for the ECT (-0.96) in this model indicates that about 96% of short-term deviations are self-correcting in the steady state. Thus, about 96% of adjustment to steady state equilibrium takes place in a year following a divergence in the short term. The model's plots of Cumulative sum of recursive residuals (CUSUM) and Cumulative sum of squares of recursive residuals (CUSUMQ) tests indicate that the intercept of the regression equation, the slope coefficients as well as the variance of the stochastic disturbances are stable over time.

## 4. Conclusion and Recommendations

The results of this study revealed that female labour force participation rate and male labour force participation rate exert positive and significant impact on economic growth in the short-term while total labour force participation rate exerts an inverse and significant impact on growth in the same period. The long-term dynamics on the other hand revealed existence of positive but insignificant relationship between female labour force participation and economic growth as well as male labour force participation rate and economic growth. Total labour force participation rate on the other hand revealed a negative but also insignificant impact on economic growth. We therefore recommend the adoption of short-term and long-term policies to stimulate and sustain growth in the economy.The result of the short term and long term estimates as well as the insignificance results in the steady state is a pointer to the fact that the economy should focus not only on the present period but also the future in order to achieve desirable results and that continuous investment in the girl-child participation in STEM will generate favourable outcome to economic well-being.

The quest to increase the involvement of female in STEM relative to men and achieve favourable outcome in the totality of labour force participation rates will require the adoption of programmes to provide training, workshops and seminars for the working population in the economy to record improvement in the quality of their output which has implications for steering the pace and distribution of income in the economy. Also, imperative for policy makers to ensure a positive association between real gross domestic product and total labour force participation is the improvement in the human capital measured in terms of nutrition, education and health of the working population as well as improvement in their quality of life and well-being.

Scholarship opportunities in STEM should also be increased to female aspirants to increase female participation in the fields. Role models should also be encouraged to hold discussion with female students and encourage them to pursue professions in STEM. There is also the need to enlighten females right from adolescence and possibly childhood on the adverse impacts of stereotypes, lack of confidence, self-esteem and male chauvinism. With female population as percentage of total population of 49.3% (World Bank, 2019), increasing female employment in STEM in the economy is as relevant as male employment in order to hasten the pace and distribution of growth in the country and also record a satisfactory improvement in the totality of labour force participation rates in the economy.

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