Bullion

Volume 45 | Number 4 Article 2

12-2021

Does technological innovations affect unemployment in Nigeria?

Ebunoluwa O. Oyegoke
Nile University of Nigeria, FCT Abuja, saoyeboade@cbn.gov.ng

Wasiu A. Yusuf
Nile University of Nigeria, FCT Abuja

Recommended Citation
Oyegoke, E.O. & Wasiu, W.A. (2021). Does technological innovations affect unemployment in Nigeria? CBN Bullion, 45 (40), 13 - 24.

Does Technological Innovations Affect Unemployment in Nigeria?

Ebunoluwa O. Oyegoke,
Nile University of Nigeria, FCT Abuja
Ebunoluwaoyegoke@nileuniverstiy.edu.ng

Wasiu A. Yusuf
Nile University of Nigeria, FCT Abuja

ABSTRACT

This study examines the effects of technological innovations on unemployment in Nigeria using annual time series data 1980-2018, Autoregressive Distributed Lag and cointegration bound testing approach. Technological innovations was proxied by the inflow of FDI; importation of Machinery and Equipment as indicator for process innovation (ETC), Patent represents product innovation, while Total Factor Productivity serves as the exogenous technical progress in line with Solow. The result shows that the coefficient of the Inward Foreign Direct Investments (INFDI) is positive (3.85), which is significant at 5%, indicating a strong positive effect of process innovation on Unemployment. Machinery & Equipment was also positive (2.87) and it's significant at 5%. However, Patent (-1.20) has a negative and significant effect on unemployment. By implication, process innovation (with Embodied Technological Change, potentially substitutes labour), therefore, raises unemployment, while product innovation reduces unemployment in Nigeria. There is need to invest more on in-house innovation via R&D activities by, upgrading the learning and skill acquisition standard of the country, and also supporting innovative ventures through discoveries, mentorship, provision of capital and macroeconomic stable environment.

Keywords: *Technological innovation, Process innovation, Product innovation, Unemployment, ARDL*

JEL: *Classification: E24, O33*

INTRODUCTION

Background to the Study

The world marketplace has taken a new turn with the advancement of technology. Technological innovation has changed the nature of production and trade, as Industrialization is gradually becoming more capital-intensive, largely due to the discoveries of machineries and technology, as such, has an overwhelming effect on the labour force. New economy emergence has been characterized by increase in productivity and output level, largely driven by progress in technological innovations and inventions.

Innovation on its' own is a broad concept which allows for the development of extra or additional steps to increase production in stages. It is the ability to introduce or develop new ways of production of products and services which are useful for accomplishing goals and objectives. It is also a new process of achieving an old task. Therefore, technological innovation is the technological aspect of innovation which emphasizes the use of technology as the key determinant of growth. In the business world, technological innovation is simply a new and improved way of achieving or accomplishing traditional tasks. Conventionally, the most important source of growth in economics is technological change (Todaro & Smith, 2013). The invention of new technology is a form of technological innovation; progress in technology changes the process of production of firm's overtime (Perloff, 2012).

Technological change is a series of stages with multiple actors, relationships and feedback loops- from the invention, as new technology is created and prototyped, to innovation as it becomes commercially viable (UNIDO, Industrial Development Reports, 2011)'

A large percentage of the growth and increase in productivity across the globe is accounted for by improved technological innovation. An undeniable fact is that technology makes production easier, faster and less costly when compared to human ability, with regards to some cognitive and routine jobs. Technological change is revolutionary with each phase significantly impacting on the world economies both positively and negatively. Developed countries have mostly utilized the transformational benefits embedded in technological innovation. China, for instance, is considered as the 'future market' by 2025, and Germany remains one of the key drivers of growth and development of the European economy. Technological innovation can be divided into four main types, according to (Oslo Manual, 2005) they are Product innovation, Process innovation, Marketing, and Organizational innovation. However, the study focuses on determining the connection between technological innovation and unemployment, hence, the main concern is the first categories: product and process innovation. Product innovation: is described as the birth, evolution and emergence of new breakthroughs, products, goods and services. (Matuzeviciute, Mindaugas, & Karaliute, 2017). Product innovation improves lives and allows for ease (Ramanauskienė,2010). A good example of product innovation is the ATM machine, telegraph, mobile phones, cars, etc. It opens new opportunities and a great chance for progress.

Process Innovation: this involves a new method, new technologies and new ways of production of goods and services. It is a new and improved way of performing an old task to achieve a better result and enhance overall performance. Automatic data processing and recording have replaced the old-fashioned way of 'back office' activities. Also, the increased use of artificial intelligence and robotic use are parts of the process innovation of technological growth. Robots tend to be more precise than humans and cost less in the long run (Brzeski & Burk, 2015). Robots designed for production have self-learning abilities. These further stresses the importance of innovation, research and development, and technological advancement for economic growth and development. What distinguishes the economies of developed and developing countries is 'technological innovation'. Technologically advanced countries continue to sustain and improve their economies especially, entrepreneurship by developing internal technology, suitable for the economic condition.

A good example is Singapore, which has been established as a hub for innovation and entrepreneurship and ranked by World Bank as number one with ease of doing business in the world. Singapore as a country has developed a technology plan which spans for five years, the most recent was developed in 2016-2020, with S$19 billion budgeted for research and technological innovation up from $16.1billion from the previous year. (EEN, 2019). Singapore has succeeded in proving that technological innovation may not necessarily lead to unemployment given that the unemployment rate is about 0.8% in 2018 and in 2017, it was 0.7%. This is still not far from the natural rate of unemployment in economics.

Most developing countries, on the other hand, keep relying on FDI, (foreign direct investment), that is, most Developing Countries (DCs) import technologies via investment in machinery and capital goods and foreign investments into their countries. The importation of technology hinders development in the long run thereby depriving the home country of the opportunity to be self-sufficient and self-reliant. It requires more capital and hence, leads to an increase in the unit cost of production which increases the prices of the final goods and services. Certainly, the future of the product markets and the labour markets depend largely on the impact of technological development in years to come (as it has been) (Solow, 1957) (Romer, 1990). For countries to compete internationally and increase productivity and economic growth, their level of investment in technology through R&D activities will influence their performance. In this digital age, every economy is a product of her level of research and development, innovation and technology. Modern economies and productivity are dependent on technological input and other factors of production. It is widely believed that, although improvement in digital technology results in high productivity, a contrasting view still holds of its' detrimental effect on the future of the labour market, with respect to the sustainability of the human labour, job security, and the future of employment of the generations to come.

Empirical findings on how technological innovation affects employment are disintegrating. Some researchers have identified the second-order effect of technological innovation which creates new products and new demand, thereby creating new jobs (Miller & Atkinson, 2013) (Harrison, Ruperti, Jaumandreu, Mairesse, & Peters, 2008) (Vivarelli, 2014). On the other hand, others argue that although advancement in technology aids production by making it faster and easier, it will result in technological unemployment (Matuzeviciute et al 2017) (Keynes, 1933). Globally, advancement in technology has taken a new turn with the advent of the fourth industrial revolution (Industry 4.0).

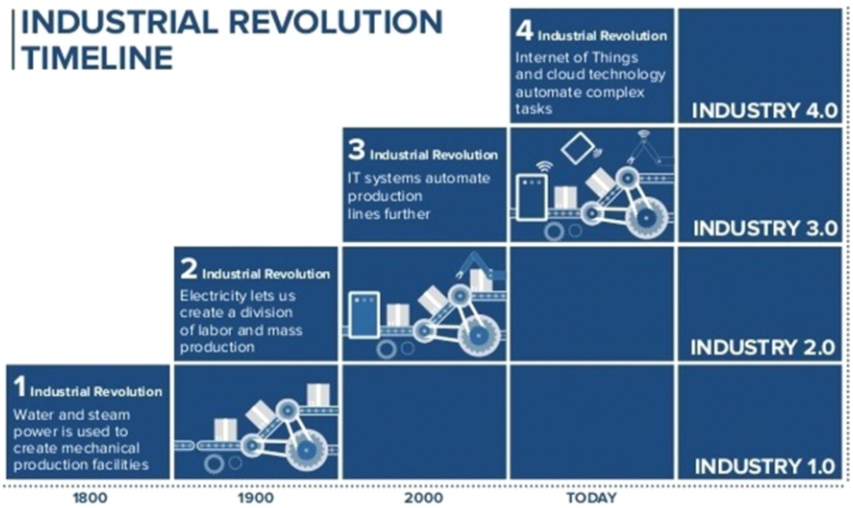
There is the fear of job displacement in this era, which as a result of innovations, which can be described as daunting, and has received global attention in modern times. More evidently, the fourth industrial revolution might represent Schumpeter's 'Creative Destruction'. In Germany, the launching of the 4th Industrial revolution, (Industry 4.0) has birthed a new dimension of research, with a focus on Robots. The growing concern is the effect of robotization on employment: Recent studies confirm the use of robots in carrying out tasks that were conventionally performed by humans both in the workplace and at the home front (Brzeski & Burk, 2015).

Since the cyclical nature of an economy includes recession at one time and boom at another, job creation and destruction are therefore inevitable, and part of the economy's reaction to change. In developing countries, one major characteristic that is similar to all is that job growth remains stubbornly anemic. The general belief since the time of the Neo-Luddite is that technological change affects job growth. In their opinion, the advancement in technology is the cause of job destruction which results in technological unemployment. The advent of the first industrial revolution was rejected by the English workers back in the days, emphasizing that machines and other equipment must be destroyed to protect the labour market. Furthermore, Low-income countries are more susceptible and vulnerable to automation compared to high-income countries(Milington, 2017).

The risk of automation is higher; likewise, the effect on demand for labour will be altered if the right technology is not employed. In the 19th and 20th century, automation and computerization bolstered job creation. During this period, technology was more of a complement than a replacement of labour, hence, enhanced development overall. For example, In Nigeria, the advent of Global System of Mobile Telecommunication (GSM) and the internet contributed immensely to trade and general productivity of the economy, by easing the pressure of communication between the buyers and sellers.

In addition, the fact that digitalization and computerization may result in job destruction in the future in an unprecedented way is the main concern of the 'techno-pessimistic' group of people. This is because the innovations of the 19th and 20th century complemented labour in a commendable way. But the same cannot be said of the twenty-first (21st) century technological innovation, which is more labour-saving than labour-augmenting. An in-depth review of the Industry 4.0: 'The Fourth Industrial Revolution' justifies the opinion of techno-pessimistic of a paradigm shift from the first through the third industrial revolution, to a revolution characterized by a fusion of digital, biological, and physical technological spheres (UNIDO, 2018).

Figure 1: Industrial Revolution Timeline



Source: Daxue Consulting 2019

Figure 2: Nigeria- Innovation Index

Source: TheGlobalEconomy.com, Cornell University, INSEAD and WIPO 2019

Undoubtedly, Nigeria has a long way to go in embracing the concept of innovation in totality, especially, product innovation which has been established to bolster job creation globally. However, there is emerging evidence of new technology gaining grounds. Therefore, given that the pace of technological development is radical, and the high percentage of jobs at risk in the country presently, how prepared is Nigeria for technological unemployment? Will technological innovation enhance or substitute labour in Nigeria? Is technological advancement a threat to the Nigerian labour force? Can the persistent rise in unemployment be attributed to technological change? If the new innovation and technology become cheaper, are we prepared for the future? The past and present literature on whether, technological innovation complements or substitutes labour is highly 'controversial'.

It is a tenet that has remained debatable and inconclusive. Many scholars believe that technological advancement results in mass job destruction, See((Stuart , 2007), (Lanier, 2013) (Frey & Osborne, 2017), (Arntz, Gregory, & Zierahn, 2016), (Acemoglu & Restrepo, Robots and Jobs: Evidence from US Labour Market, 2017) (Citi, 2016); others believe that technical change is skill-biased, hence results in polarization of the middle-skill jobs, thereby leading to inequality, (Dachs, 2018) (Santos, 2016). On the other hand, the majority believe that advancement in automation and technology are no threat to employment, on the contrary, robots, machine productivity and automation are key drivers of human progress, (Miller & Atkinson, 2013) (Pankaj, 2018) (Danaher, 2017) (Piva & Vivarelli, 2018) In contemporary research studies, the issue of technological advancement and labour saving is 'inconclusive', that is, technological innovation is neither good nor bad on employment, wages and human labour at large (Acemoglu, 2010) (Michael et al, 2017).

In the case of Developing Countries like Nigeria, innovation has been characterized by more of Embodied Technological Change (ETC) than R&D given our overdependence on importation as well as our taste for foreign goods. Therefore, following the recent studies of (Matuzeviciute, Mindaugas, & Karaliute, 2017), (Bogliacino, 2014) (Dahlman & Chen, 2004), this study examines and assess the relationship between the unemployment and technological innovation in Nigeria, with focus on whether or not increase in technology has substituted or enhanced labour in Nigeria. The study will further examine the effects of product and process innovation on unemployment growth rate in Nigeria.

The Keynesian school of thought also raised concerns about the widespread technological unemployment by Keynes. According to Keynes,

> *"Due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 1933).*

The Keynesian school of thought holds that the discovery of new machinery will possibly destroy the relevance of human labour by displacement of jobs initially performed by a human. Keynes postulations on technological innovation created the awareness of the discovery of machineries that accelerate and enhances productivity, however, might result in detrimental effect on the labour force.

Similarly, there is increasing evidence that the labour markets are hollowing out. According to (Frey & Osborne, 2017), using the occupation-based approach to test for the susceptibility of jobs in the US, the result shows that about 47 per cent of occupations in the US are potentially automatable to replacement by automation, a projection for the next 10 to 20 years to come. Results from a cross-country occupational structure differences shows that about 35.7 per cent of Finland corresponding share of employment is at the high-risk of automation (Pajarinen & Rouvinen, 2014), out of a total of 30.9 million social insurance companies estimated in Germany labour force, 18.3 million of the jobs which were marginally employed in the analysis stands a high-risk of automation of about 59% (Brzeski & Burk, 2015).

METHODOLOGY

Sources of Data and Methods of Data Analysis

This study, employed secondary data which were sourced from: the National Bureau of Statistics (NBS), World Development Indicators (WDI) (World Bank, 2019)E, Penn World Table version 9, (Robert, Robert , & Timmer, PWT 9.0, 2015), Federal Ministry of Trade and Investment, and the Global Economy (The Global Economy, 2019). The variables employed for the study are:

I Unemployment growth rate (percentage of the labour force)

ii. FDI (foreign direct investment(inflow)) (BOP current US$)

iii. PA (Patent) (Total number of registration)

iv. TFP (Total factor productivity in rate)

v. M_E (Machinery and Equipment importation in million Naira)

The unemployment growth rate is the dependent variable; it represents the total percentage of the labour force that is willing and able to work but couldn't get jobs. If the result shows a negative coefficient, then innovation reduces unemployment, hence, and it's therefore a complement; however, if it's positive, then it's a substitute. The FDI is one of the ways through which developing countries experience the transfer of technological innovation into their countries, via importation of capital and intermediate goods, machineries and equipment, and other capital imports. It is a part of the Embodied Technological Change (ETC) as explained by (Barbieri, Piva, & Vivarelli, 2016) particularly for DCs. Hence inward FDI could also proxy for process innovation in developing countries.

The patent which was described as the output of research and development activities; it is a variable of choice because it is one of the commonly used proxies for technological innovation by researchers. Patent and Intellectual Property Rights are being considered as the best way to measure technological diffusion and innovation, see (Jalles, 2010). Total Factor Productivity (TFP) is another proxy for innovation and has been included in this study based on (Solow, 1957) findings, it accounts for the technological progress which is determined exogenously.

Table 1: The summary of the model is given below:

Variables	Definition	Measurement
Dependent Variable	Unemployment (unemploy)	Total (% of labour force)
Independent variables	Inward Foreign Direct Investment(FDIin)	BOP current US$
	Patent Registration	Total Number registered per year
	Machinery and Equipment (M_E)	Million Naira
	Total Factor Productivity(CTFP)	TFP at constant national prices (2011=1)

Source: Author's computation (2019

The model specification in a log linear form for long-run is given as:

$$UN_t = \alpha_0 + \alpha_1 PA_{t-1} + \alpha_2 LnFDIin_{t-1} + \alpha_3 TFP_{t-1} + \alpha_4 LnM\_E_{t-1} + \mu_t \qquad (1)$$

Where: UN = Unemployment rate, PA = Patent, InFD = Foreign direct investment inflow, TFP = Total factor productivity, M_E = Machinery and Equipment, α_0 = The intercept, while $\alpha_1 - \alpha_4$ = the slope, μ_t = the random error

The ARDL estimation technique is a linear analytical tool used for time series models which specify the contemporary and the historical relationship between the endogenous and exogenous variables. The ARDL models are also well known for examining the cointegrating relationships among variables (Pesaran & Shin, 1998), irrespective of their orders of integration I(0(1)).

The model was analysed using ARDL cointegration technique. This ARDL method of estimation is preferred having satisfied the I(0) and I(1) condition among the series.

Short-run RECM (Restricted Error Correction Model) is given as:

$$\Delta UN_t = \alpha_0 + \omega E\hat{C}T_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta UN_{t-1} + \sum_{i=1}^{p_1} \beta_i \Delta PA_{t-1} + \sum_{i=1}^{p_2} \gamma_i \Delta TFP_{t-1} + \sum_{i=1}^{p_3} \delta_i \Delta \ln FDIin_{t-1}$$
$$+ \sum_{i=1}^{p_4} \psi_i \Delta \ln \underline{M} \quad E_{t-1} + \ell_t \qquad (2)$$

While the UECM (Unrestricted Error Correction Model) is given as:

$$\Delta UN_t = \alpha_0 + \sum_{i=1}^{q} \alpha_{1i} \Delta UN_{t-1} + \sum_{i=1}^{p_1} \alpha_2 \Delta PA_{t-1} + \sum_{i=1}^{p_2} \alpha_3 \Delta TFP_{t-1} + \sum_{i=1}^{p_3} \alpha_4 \Delta \ln FDIin_{t-1}$$
$$+ \sum_{i=1}^{p_4} \Delta \ln M\_E_{t-1} + \beta_1 UN_{t-1} + \beta_2 PA_{t-1} + \beta_3 TFP_{t-1} + \beta_4 \ln FDIin_{t-1} + \beta_5 \ln M\_E_{t-1}$$
$$+ \mu_t \qquad (3)$$

Theoretically, process innovation, (ETC) via investment in capital equipment and machinery which is mainly imported through the mechanism of FDI (inflow) and is expected to have a positive relationship with unemployment; Product innovation (proxy by patent) is expected to reduce unemployment, while process innovation increases unemployment. Total Factor Productivity (TFP) measures the residual growth, explains the long-run growth of the economy, and accounts for progress in productivity, it is expected to relate with unemployment negatively.

RESULTS AND DISCUSSIONS

Table 2: Augmented-Dickey Fuller Unit Root Test (Summary)

Variable	Stationary	Order of stationary	Significance level	Probability
Unemployment	Yes	I(0)	5%	0.0142
FDI inflow	Yes	I(1)	1%	0.0000
Patent	Yes	I(1)	5%	0.0000
M_E	Yes	I(1)	1%	0.0000
Total Factor Productivity	Yes	1(1)	1%	0.0000

Source: Author's Computation (2019) (Eviews 10SV)

The Augmented Dickey-Fuller unit root test shows that none of the five variables have unit root. variables are integrated of order I(0) and I(1) (see Table 2). The analysis has been done at the Aggregate/ Macro level; hence we are testing the overall effect of innovations on labour using unemployment. In Table 3, the ARDL estimation result shows that the coefficients of the Inward Foreign Direct Investments (INFDI) are positive (3.85), with the probability value of (0.0000) indicating a strong positive effect of process innovation on Unemployment. While that of Machinery & Equipment is also positive (2.87), with a P-value of (0.0014) showing a statistical significance of having a positive impact on unemployment in Nigeria, and significant at 1%. Patents, on the other hand, have a negative and significant effect on unemployment. The coefficient of the patent is (-1.24), with a probability value of 0.0478 indicating a statistical significance at 5%. The effect of TFP as a proxy for innovation is mixed. For the current year and the first lagged period, result shows that there is a negative relationship between unemployment and TFP, (-1.2, -0.03), however, not significant, (given the P-value of 0.52 and 0.99 respectively), while the coefficient of the second lagged period is negative (-17.85), and significant at 1%. TFP for the third lagged period has a positive coefficient and not significant (see Table 4).

Table 3: ECM Regression Result (Short run analysis)

Variables	Coefficient	Std. Error	t-Statistic	Prob*
D(UN(-1))	4.255835	0.469726	9.060256	0.0000
D(UN(-2))	2.613900	0.371440	7.037200	0.0000
D(CTFP)	-1.359484	1.399856	-0.971160	0.3544
DCTFP (-1))	15.939191	2.440192	-0.940166	0.0001
D(CTFP (-2))	-1.940621	2.064126	-0.940166	0.3693
D(LNFDI)	3.898749	0.334092	11.669694	0.0000
D(LNFDI(-1))	3.370343	0.535176	6.297630	0.0001
D(LNFDI(-2))	3.593022	0.550160	6.530863	0.0001
D(LNM_E)	2.612343	0.443259	5.893486	0.0002
D(LNPA)	-1.248309	0.285772	-4.368204	0.0014
CointEq(1)*	-5.959384	0.649734	-9.172030	0.0000

Cointeq = UN – (-2.8829*CTFP + 0.1332*LNFDI + 0.5138*LN_ME -0.2157*LNPA + 2.7364)

Source: Author's Computation (2019) (Eviews 10SV)

Table 4: the ARDL Estimation Results
Dynamic regressors (3 lags, automatic): 3 (Automatic selection)

Variables	Coefficient	Std. Error	t-Statistic	Prob*
UN (-1)	-0.600120	0.281849	-2.129226	0.0591
UN (-2)	-1.616634	0.429180	-3.766799	0.0037
UN (-3)	-2.362768	0.820543	-2.879517	0.0164
CTFP	-1.289368	1.937446	-0.665499	0.5208
CTFP (-1)	-0.031525	2.598596	-0.012132	0.9906
CTFP (-2)	-17.85359	4.247951	-4.202850	0.0018
CTFP(-3)	3.089202	2.419910	1.276577	0.2306
LNFDI	3.854944	0.531331	7.255259	0.0000
LNFDI(-1)	-0.004913	0.640807	-0.007667	0.9940
LNFDI(-2)	0.159177	0.553858	0.287397	0.7797
LNFDI(-3)	-3.266146	0.703969	-4.639614	0.0009
LNM_E	2.866870	0.654495	4.380275	0.0014
LNPA	-1.203407	0.533827	-2.254300	0.0478
C	15.2673	16.19734	0.942619	0.3681

R-squared	0.982016	Mean dependent var	10.54775
Adjusted R-squared	0.958638	S. D. dependent var	2.889029
S.E. of regression	0.587563	Akaike info criterion	2.065531
Sum squared resid	3.452303	Schwarz criterion	2.752730
Log likelihood	-10.78638	Hannan-Quinn criter.	2.247845
F-statistic	42.00472	Durbin-Watson	1.941776
Prob(F-statistic)	0.000001		

Source: Author's Computation (2019) (Eviews 10SV)

The result also reveals that the Total Factor Productivity (CTFP) which according to (Solow, 1957) represents technological progress has a negative impact on unemployment, but not significant. The coefficient of the TFP is (-1.289) with the probability value of 0.5208, which indicates its' insignificance statistically. Recall that TFP is described as an indicator of 'Technical Change' which accounts for the short-run and long-run economic growth (Solow, 1957), and has been proven empirically to reflect actual technological growth (ceteris paribus) (Ceyhun & Cakir, 2014).

More so, evidence from the regression reveals that there is a strong and positive relationship between unemployment and inward FDI. A unit increase in the inflow of FDI into the country increases unemployment by 39%. This conforms to the a priori expectation, however, this is in contrast with the findings of (Matuzeviciute, Mindaugas, & Karaliute, 2017) (Lipsey, Sjoholm, & Sun, 2010) (Fieldmann, 2013) that reveal that inward FDI is negatively related to the unemployment growth rate.

Perhaps, the difference in these findings can be attributed to the development stage of the countries sampled, as well as the macroeconomic structure and its' effect on the labour force. Most of these empirical results are estimated on technologically advanced countries that invest heavily on in-house innovations hence, a negative effect is expected. However, in the case of DCs, as earlier established empirically, for most DCs, the dominant form of technological innovation is the Embodied Technological Change (ETCs) via importation new technologies (Capital goods, machinery and others) from developed countries (Vivarelli, 2012).

In general terms, since most of the technologies are imported, we can imply that technological spill-over and 'Catch-up' substantially account for innovations in DCs, therefore the predominant source is the process innovation which has a productive but job destruction effect on the host countries.

The result of this study further justifies the predictions of (Vivarelli, 2015) (Vivarelli, 2012), that process innovation results in technological unemployment, as it is the case of Nigeria, there is a strong positive relationship between inward FDI (Proxy for technological innovation) and unemployment.

As FDI inflow increases by one unit, the unemployment rate in return increases by 3.85 units. Patents which represent the output of R&D activities in the country as described by (Vivarelli, 2015), and been considered as the reflection of product innovation which has the job-creation effect, has been justified from the regression results. In other words, patent activities relatively in Nigeria have a complementary impact on labour. A unit increase in patent activities results in about 1.2-unit reduction in unemployment in Nigeria. Finally, importation of machinery and equipment which also represents the Embodied Technological Change (ETC) justifies the job destruction effects of process innovation. The regression result shows that a unit increase in the importation of Machinery increases the unemployment rate by 2.87 units and is statistically significant at 1% level of significance.

Summary and Conclusion

This study examines the impact of technological innovation on unemployment in Nigeria. The primary focus of the study is to determine if technological change complements or substitutes labour in Nigeria. Findings suggest that the effects of technological innovation on the labour force are two folds: positive and negative, and these effects are influenced mainly by the type of technological innovation employed at that time. The results show that technological innovation can lead to "technological unemployment" Product innovation, on the one hand, enhances labour while process innovation on the other hand potentially renders labour obsolete.

Technological innovation can be detrimental to the economy either directly or indirectly. The impact of technological innovation on labour and social growth of the country depends on the type of technological innovation, the economic institutional mechanism, structure of the country, the channel through which innovation is produced and acquired, human capital development, and a host of others. Economic research have revealed that as profitable as technological innovations might be to productivity and development, they are not void of consequences. One major consequence of innovation is the direct effect on employment, which has been identified as "Technological Unemployment (as earlier discussed).

Therefore, in this study, we have contributed to the existing literature on the debate about the impact of technological innovation on unemployment. Most empirical research has been carried out at the micro-level and the sectoral level, only a few pieces of research have been done on the macroeconomic effect of innovation on unemployment. Findings also are divergent on the results, while some suggest a strong positive impact, (Fieldmann, 2013), some findings reveal that there is no clear evidence on the impact of innovations on unemployment (Matuzeviciute, et al 2017).

However, the regression results indicate that overall, there are short and the long-run relationship between technological innovation and the labour force, technological innovations, can have both positive and negative impact on the labour force, depending on the type of innovation. In quantitative terms, process innovation (proxy by inward FDI and importation of M_E) has labour-saving effects on the labour force in Nigeria, hence a substitute. While product innovation (proxy by patents) has a labour-augmenting effect on the labour force in aggregate terms, hence, a complement.

Recommendations

Technological unemployment can be avoided if the focus is more on labour-friendly innovations, rather than labour-saving. This is possible when in-house Research and Development activities (R&D) are encouraged at all levels. This will bolster job creation by enhancing the introduction of new products, firms and jobs.

Secondly, with regards to inward FDI, the introduction of new technology, as well as the importation of equipment and machinery, might be a key contributory factor to the upsurge of unemployment in most developing countries. More so, evident in the analysis is the sign of the positive effect of inward FDI on unemployment in Nigeria, these results underscore the need to stimulate innovation activities aimed at providing, increasing and stimulating employment in Nigeria.

Given the creative destruction effect of the introduction of new Embodied Technological Change (ETC), technology adaptation rather than outright adoption is more suitable for Nigeria. In other words, it is a fact that importation of technology is a crucial driver of technological innovation in Nigeria, however, adapting and modifying these new technologies will be instrumental in minimizing its' labour-saving effect.

Conclusively, the economy cannot thrive without technology, it is therefore expedient to carefully select the best type of technology most suitable for a country like Nigeria, with high level of youth unemployment. Advancement in technology is ever-increasing, but its' maximum impact is time-bound (World Trade Reports, 2017).

The wave of technology from the first up to the third industrial revolution has had long-lasting effects on production, but full manifestation took a while, implying that the current wave of technological progress, especially the most feared fourth industrial revolution is perceived to have a potentially destructive nature, and at the same time, make production easier, faster, and cheaper. Therefore, the effect of technological innovation is ambiguous.

REFERENCES

Bibliography

Acemoglu, D. (2010). When Does Labour Scarcity Encourage Innovation? *Massachusetts Institute of Technology* .

Acemoglu, D., & Restrepo, P. (2017). Robots and Jobs: Evidence from US Labour Market. *National Bereau of Economic Research*(23285), 1-91.

Arntz, M., Gregory, T., & Zierahn, U. (2016). The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. *OECD Social Employment and Migration Working Papers, No. 189,* 1-34.

Barbieri, L., Piva, M., & Vivarelli, M. (2016). R&D, Embodied Technological Change, and Employment: Evidence from Italian Microdata. *IZA DP, No. 10354,* 1-34.

Bogliacino, F. (2014). Innovation and Employment: A Firm level Analysis with European R&D Scoreboard data. *EconomiA: Elsevier, 15*(2), 141-154.

Brzeski, C., & Burk, L. (2015). The Robots Come, Consequences of Automation for The German Labour Market. *ING DiBa Economic Research.*

Ceyhun, E., & Cakir, S. (2014, July). Technological Progress and Scientific Indicators: A Panel Data Analysis. *Economics of Innovation and New Technology, 24*(3), 263-281.

Citi. (2016). *Global Informed Public.* Citi GPS: Global Perpective & Solution.Dachs, B. (2018). The Impact of New Technologies on the Labour Market and the Social Economy. Science and technology Options Assessment.

Dahlman, C. J., & Chen, D. H. (2004, August). Knowledge and Development: A Cross-Section Approach. 3366.

Danaher, J. (2017, Februaury). Will Life Be Worth Living in a World Without Work? Technological Unemployment and The Meaning of Life. *Springer, 23*(1), 41-64.

EEN. (2019). *Enterprise Europe Network.* Retrieved March 29, 2019, from Enterprise Europe Network: http://www.een-singapore.sg/business-support/technology-innovation

Fieldmann, H. (2013). Technological Unemployment in Industrial Countries. *Journal of Evolutionary Economics, 23,* 1099-126.

Frey, C. b., & Osborne, M. A. (2017). The Future of Employment: How Susceptible are Jobs to Computerisation? *Technological Forecasting and Social Change, 114*(C), 254-280.

Harrison, Ruperti, Jaumandreu, J., Mairesse, J., & Peters, B. (2008). Does Innovation Stimulate Employment? A Firm-level Analysis Using Comparable Micro Data on Four European Countries. *NBER Working Paper 14216.*

Jalles, J. T. (2010). How to Measure Innovation? New Evidence of the Technology-Growth Linkage. *Elsevier: Research in Economics, 64*(2), 81-96.

Keynes, J. M. (1933). *Economic Possibilities for our Grandchildren (1930).*

Lanier, J. (2013). *Who owns the Future?* New York: Simon & Schuster.

Lipsey, R. E., Sjoholm, F., & Sun, J. (2010). Foreign Ownership and Employment Growth in indonesian Manufacturing. *NBER Working Paper, 15936.*

Matuzeviciute, K., Mindaugas, B., & Karaliute, A. (2017). Do Technological Innovations affect Unemployment? Some Empirical from European Countries. *Economies, 5*(4), 48.

Michael et al. (2017). Service Robotics and Human Labor: A First Technological Assessment. *Robotics and Automation System,* 87, 348-354.

Milington, K. A. (2017). *How changes in technology and automation wil affect the labour market in Africa.* K4D Helpdesk Report. Brighton, UK: Institute of Development Studies p 14-17.

Miller, B., & Atkinson, R. D. (2013). *Are Robots Taking Our Jobs or Making Them?* The Information Technology and Innovation Foundation.

OECD and Statistical Office of the European Communities. (2005). *Guidelines for Collecting and Interpreting Innovation Data, 3rd, ed.* Paris: OECD Publishing.

Pajarinen, M., & Rouvinen, P. (2014, January 13). Computerization Threatens One Third of Finnish Employment. *ETLA BRIEF No.22,* 1-6.

Pankaj, V. (2018, June). Destruction or Polarization: Estimating The Impact of technology on Jobs in Indian Manufacturing. *Indian Journal of Labour Economics, 61* (185 (2)), 227-230.

Perloff, J. M. (2012). *Microeconomics* (Sixth ed.). Essex: Pearson Education Limited.

Pesaran, H. M., & Shin, Y. (1998). An Autoregressive Distributed Lag Modelling: Approach to Cointegration Analysis. *Econometric Society Monographs, 31,* 371-413.

Piva, M., & Vivarelli, M. (2018, March). Technological Change and Employment: Is Europe ready for the Challenge? *Eurasian Business Review, 8*(1), 13-32.

Robert, F. C., Robert , I., & Timmer, M. P. (2015). "The Next Generation of the Penn World Table" American Economic Review. *The Penn World Table (PWT V 09), 105(10),* 3150-3182.

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy.*

Santos, I. (2016, 10 06). *Labor Market Polarization in Developing Countries: Challenges Ahead.* Retrieved 01 04, 2019, from www.worldbank.org: http://blogs.worldbank.org/developmenttalk

Solow, R. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39*(3), 312-320.

Stuart , E. W. (2007). Projecting the Impact of Computers on Work in 2030. *National Research Council,* 1-38.

Todaro, M. P., & Smith, S. C. (2013). *Economic Development P(128-132)* (11th ed.). Addison-Wesley: An imprint of PEARSON.

UNIDO. (2011). Industrial Energy Efficiency for Sustainable Wealth Creation, Capturing Environmental, Economic and Social Dividends. *United Nations Industrial Development Organization.* Vienna: UNIDO.

UNIDO. (2018). Industry 4.0: Opportunities and Challenges of the New Industrial Revolution for Developing Countries and Economies in Transition: Panel Discussion. *17th UNIDO General Conference* (pp. 1-45). Austria: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION.

Vivarelli, M. (2012, January). Innovation, Employment and Skills in Advanced and Developing Countries: A Survey of the Literature. *IZA Discussion Paper, No. 6291*.

Vivarelli, M. (2014). Innovation, Eployment and Skills in Advanced and Developing Countries: A Survey of Economic Literature. *IZA Discussion Papers, 6269,* 123-54.

Vivarelli, M. (2015). Innovation and Employment: Technological Unemployment is not inevitable, some innovation creates jobs, and some Job destruction can be avoided. *IZA World of Labor, 154,* 1-10.

World Trade Reports. (2017). *Impact of Technology on Labour Outcomes: TRADE, TECHNOLOGY AND JOBS*. WORLD TRADE.

APPENDIX

Table 5: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-45.22429	NA	3.871609	4.185357	4.430785	4.250469
1	-40.39590	7.242581	2.827162	3.866325	4.160838	3.944459
2	-39.71404	0.965962	2.922386	3.892837	4.236436	3.983994
3	-34.76760	6.595262	2.122447*	3.563966*	3.956651*	3.668146*
4	-34.70453	0.078828	2.322455	3.642044	4.083815	3.759246

*indicates lag order selected by the criterion

Table 6: ARDL Long Run Form and Bounds Test Results

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	11.77308	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	**24**	**Finite Sample: n=35**		
		10%	2.46	3.46
		5%	2.947	4.088

Source: Author's computations (Eview 10SV) 2019

Post Diagnostic Tests

Table 7: Breusch Godfrey Serial Correlation LM Test:

Null hypothesis: No serial correlation up to 2 lags

F-statistic	**0.173198**	**Prob. F(2,7)**	**0.8440**
Obs*R-squared	0.996058	Prob.Chi-Square (4)	0.6077

Table 8: Heteroskedasticity Test: Breusch-Pagan-Godfrey

Null hypothesis: Homoskedasticity

F-statistic	**3.010057**	**Prob. F(18,4)**	**0.0440**
Obs*R-squared	19.11507	Prob. Chi-Square (18)	0.1196
Scaled explained SS	2.839293	Prob. Chi-Square (18)	0.9985

Figure 3: *CUSUM Tests*