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Exploring the Dynamics of Firm Turnover in Ontario through Machine Learning and a Dynamic Logit Panel Model

Shirin Okovat

Abstract

The current study aims to analyze the turnover behavior of firms in Ontario through a combination of parametric and non-parametric models. A logistic regression was initially employed to assess the impact of firm-level characteristics on the probability of delocalization, using data from corporate income tax and payroll records of 18,000 firm samples.

To control for potential unobservable variables that may affect a firm's decision to relocate, a dynamic logit panel model was employed. The results indicate that firm-level factors, such as firm size and age, play a significant role in determining turnover behavior, offering valuable insights for policymakers to optimize economic outcomes.

Furthermore, the study utilized a random forest (RF) model to examine the impact of various factors on firm location decisions. This model was compared with artificial neural network (ANN) and decision tree (DT) models and was found to be superior, with a prediction accuracy of 81% compared to 68% for ANN.

The study also employed random forest, support vector machine (SVM), and k-nearest neighbor (k-NN) algorithms to classify firms that exit the market. The random forest algorithm was found to be the most effective in modeling firm turnover behavior, with the most important factors identified as employment size and average wage, total tangible assets, firm age, and foreign control.

Keywords: Delocalization, firm turnover, optimal location, random forest, neural network

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1. Introduction

The business subsidy programs offered by the government of Ontario are administered by different ministries and play a crucial role in sustaining economic competitiveness, attracting investment, and retaining businesses within the province. The significance of these subsidies cannot be underestimated, as many companies have indicated that without such support, they may have to relocate their operations to other regions that offer such benefits. To understand the effectiveness of these subsidies, it is essential to investigate the turnover behavior of firms. Understanding the factors that influence a firm's choice of location can aid policymakers in assessing the necessity and incremental value of government support.

The existing literature on firm turnover, exit, and transition patterns highlights that a firm's decision to relocate is influenced by both firm-specific and location-specific factors, which "push" the firm from its current location and "pull" the firm to more attractive regions (van Dijk and Pellenbarg 2000; van Wissen 2000; Brouwer et al. 2004; Erickson and Wasylenko 1980; Holl 2004b; Capasso et al. 2010). While much of the research on firm relocation has focused on macro-level analysis, examining the aggregate data of firm decisions to relocate over time, space, and sector, little attention has been paid to the decision-making process of individual firms and the impact of government policies on a firm's decision to relocate at a micro level.

This paper aims to fill this gap by focusing on the first-step analysis of firm-specific factors ("push" factors) driving the decision to delocalize using the income tax administrative data and payroll dataset in Ontario between 2003 and 2015. This study utilizes the random forest (RF) decision tree (DT) method to model the turnover behavior of Ontario firms and contribute to the existing literature with a specific outlook on methodology. The study explores the determinants of turnover behavior in Ontario firms using individual data on firm and delocalization characteristics from an initial sample of nearly 18,000 observations. A systematic literature review was conducted, examining the studies and reports relevant to understanding the probability of firms surviving or exiting, with specific attention given to articles discussing Canadian regions and the use of probit or logit, survival rate, mobility rate, and/or turnover rate.

The paper is structured as follows: the first section provides a theoretical background and formulates hypotheses on the determinants of firm delocalization, the second section details the data and methodology used, the third section presents and discusses the empirical results that test the hypotheses, and finally concludes by highlighting the guidelines for future research.

2. Literature Review

The study of firm turnover behavior has been a rich area of theoretical literature. Since the 1950s, numerous studies have been conducted on the concept of firm location and migration, with countries such as the United Kingdom, the Netherlands, Germany, Belgium, France, and Italy attracting particular attention (Pellenbarg et al., 2002). The movements of firms play a significant role in the spatial redistribution of economic activity and employment, making it essential to investigate firm relocation and delocalization. Relocation refers to movements within the same national borders, while delocalization encompasses the migration of firms, either partially or entirely, to foreign countries. Business expansion (Klaassen and Molle, 1983; Hayter, 1997), cost reduction (Chan et al., 1995), and improved access to inputs and energy sources (McCann, 2001) have been identified as primary reasons for relocation.

Firm delocalization, also referred to as offshoring or outsourcing, has garnered increased attention in the rapidly globalizing economy. The trend of relocating a portion of a firm's operations to lower-cost jurisdictions holds both potential benefits and drawbacks for both firms and host countries. The motivations behind firm delocalization have been extensively explored in the literature, with profit motives, lack of complete information, and local economic dynamics cited as contributing factors (Sleuwaegen and Pennings, 2006). Empirical studies have sought to quantify the factors that increase the likelihood of firm delocalization, such as firm size, multinational networks, foreignness of capital, sunk costs, and negative firm growth (Verma, 2018).

The exit and transition patterns of firms have been also analyzed in terms of the factors that influence relocation decisions, which have been classified as internal factors (e.g., firm size), external factors (e.g., market size), and location factors (e.g., regional characteristics) (Lloyd and Dicken, 1992). Two primary types of factors affecting relocation decisions have been distinguished: "push" and "pull" factors. "Push" factors prompt a firm to leave its current location (van Wissen, 2000), while "pull" factors draw a firm to a new location (Erickson and Wasylenko, 1980; Holl, 2004; Capasso et al., 2011). Early studies primarily focused on "pull" factors, assessing the appeal of a potential new location, but subsequent location theories have also incorporated "push" factors.

The entry and exit of firms play a critical role in shaping the industrial structure of a region. In recent years, there has been a trend of firms relocating their manufacturing operations to countries with lower labor costs, such as China, India, and Southeast Asia. However, recent shifts in trade policies and the COVID-19 pandemic have led some firms to re-evaluate the advantages of offshore manufacturing and consider relocating closer to home.

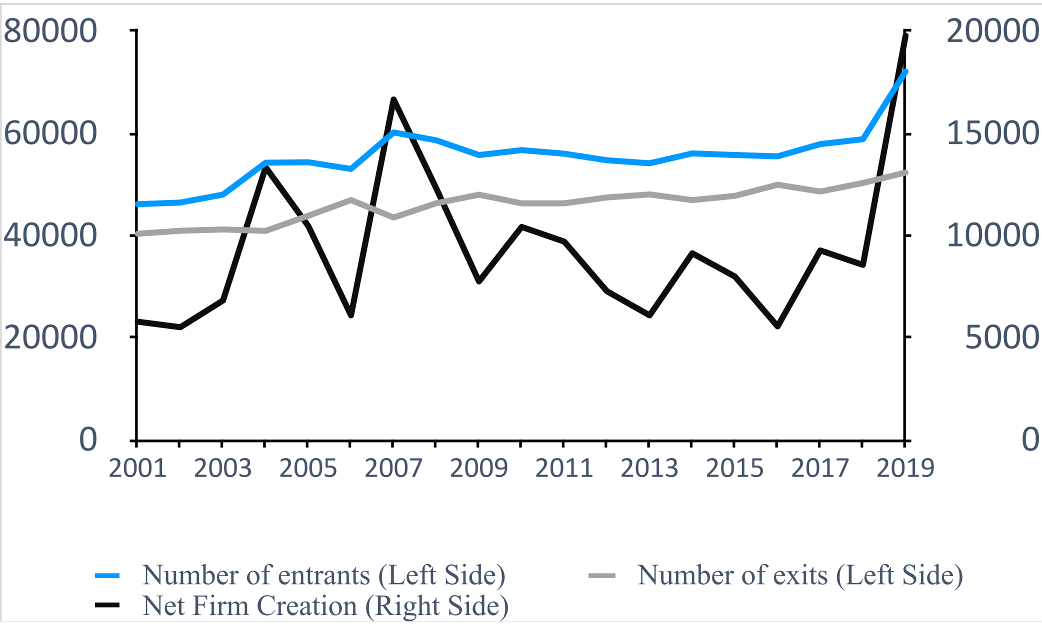
The COVID-19 pandemic has had a profound impact on firms' operations and strategies, leading to a reassessment of costs and supply chain stability (Baldwin et al., 2020). This has resulted in a trend of firms relocating back to North America from overseas, as well as moving to rural areas. The impact of firm delocalization on host countries and communities has also been explored, with job losses and reductions in the economic activity being reported effects (Bluestone and Harrison, 1982). Policymakers have attempted to address these challenges through various measures aimed at retaining businesses and promoting economic development, including access to recovery funds, promotion of remote work and digital transformation, support for workforce retraining, and fostering collaboration and innovation (Verma, 2018).

Despite the valuable insights provided by current literature on firm delocalization, there is still a need for further research to gain a more complete understanding of this phenomenon. Further investigation into the "pull" factors driving firms' decisions to move would benefit policymakers who oversee business subsidy programs, enabling more efficient allocation of resources. Machine learning models could also prove useful in predicting firm delocalization, but more observations and variables would need to be considered for practical use.

The Canadian economy experienced substantial progress in promoting entrepreneurship prior to the outbreak of the COVID-19 pandemic. High-growth "gazelle" firms, defined as businesses less than five years old with significant growth potential, play a crucial role in driving innovation and job growth in both Canada and Ontario. The economy is undergoing significant changes in terms of firm establishment and dissolution. Despite the initial impact of the pandemic, firm creation rebounded from June 2020, resulting in an increase in the number of established firms in 2020 compared to the previous year. Moreover, the number of bankruptcies declined significantly in comparison to the preceding year. However, further research is necessary to fully understand the complexities of firm delocalization and its effects on the economy

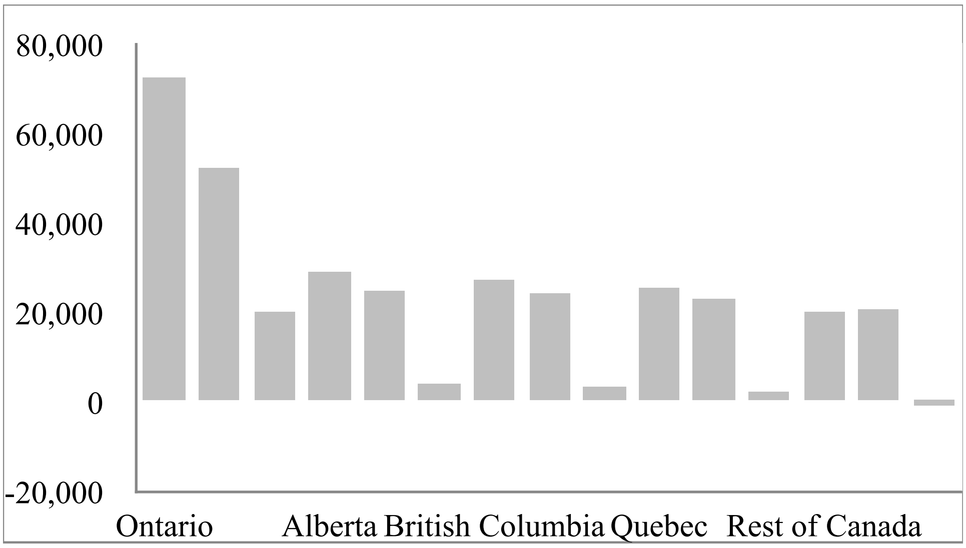
Similarly, the economy of Ontario is undergoing significant transformations, including in the realm of firm entry and exit. The rates of firm entry and exit in Ontario rose and remained relatively stable between 2001 and 2015 (refer to Chart 1). However, prior to the recession, the rate of entry was outpacing the rate of exit, potentially signalling a thriving entrepreneurship landscape and a favourable business environment. In evaluating firm turnover, it is crucial to consider both entry and exit rates, as they provide insight into the creation and destruction of firms. From 2001 to 2019, the private sector's net firm creation in Ontario, calculated as the difference between firm entry and firm exit, averaged 9,031. The largest surge in net firm creation occurred in 2019, with 19,790 new firms being established. During the 2007-09 recession, the rate of net firm creation dropped to 7,760. Although this study does not aim to examine the impact of the recession on entry and exit rates, the rate of net firm creation reached its highest level in 2019 (refer to Chart 1).

Figure 1: Ontario Firm Entry, Exit and Net Creation, 2001-2019



A noteworthy observation was made in 2019, as Ontario recorded a marked increase in net firm creation compared to all other provinces and territories. This trend is demonstrated in Chart 2.

Figure 2: Private Sector Entrants, Exits, and Net Values for Provinces, 2019



3. Location Theories and Factors Influencing Firm Delocalization

Neo-Classical Location Theory

The Neo-Classical Location Theory posits that rational firms, equipped with access to perfect information, will aim to maximize profits by selecting the optimal location for their operations. According to this theory, firm relocation is predominantly driven by the desire to reduce costs, leading to the selection of the least cost location as the rational choice. In a state of equilibrium, the optimal location is fixed and there is no requirement for further relocation. However, changes in internal and external factors that impact firm cost and revenue surfaces may alter firm profitability, thereby necessitating a search for a new equilibrium location. The concept of "push" factors, which compel a firm to relocate due to the unprofitability of its current location, and "pull" factors, which attract a firm to a more profitable location, are central to the Neo-Classical Location Theory.

Behavioural Location Theory

In contrast, the Behavioural Location Theory models firms operating under conditions of incomplete information, resulting in less than rational decision-making. Factors such as firm age, size, and sunk costs can lead firms to persist in a non-optimal location, despite decreased profitability. This theory replaces the notion of optimal location with a satisfactory location.

Institutional Location Theory

The Institutional Location Theory incorporates the social environment in which a firm is situated into the location decision-making process. The influence of local cultural institutions, existing networks, and value systems on a firm's location decision is a central tenet of this theory. The Institutional Location Theory examines the interplay between firms rather than solely focusing on a single firm's optimization decision. Economic relationships and institutional support can also play a significant role in a firm's decision to locate and its investment strategy.

According to the Institutional Location Theory, a firm's consideration of relocation goes through more than two phases. A proposed four-phase process includes: 1) the initial decision phase on whether to move or remain; 2) the search phase; 3) the evaluation phase; and 4) finalizing the choice for a new location (Dicken and Lloyd, 1977; Hayter, 1997). This paper focuses on the first phase of the process.

The following hypotheses are proposed based on the firm turnover behaviour literature that was examined on internal, external, and location decision factors.

Size

The internal factor of firm size has a significant impact on a firm's location decision making process. According to Kronenberg (2013), larger firms are often faced with greater costs associated with relocating, making them less likely to move. In contrast, smaller firms are found to be more prone to relocating, with Mason (1980) citing lower capital investments, the tendency to make "repeated small location adjustments," and an inability to expand existing facilities as key factors.

Studies by Van Dijk and Pellenbarg (2000) in the Netherlands and Brouwer et al. (2004) on a global scale both reinforce the importance of firm size in relocation decisions. Van Dijk and Pellenbarg (2000) found that firm size was a significant predictor of relocation, while Brouwer et al. (2004) showed that very large firms (with over 1,500 employees) were the least likely to relocate. On the other hand, Pennings and Sleuwaegen (2000) found that larger multi-plant firms could reap benefits from international relocation, particularly if their variable costs were low and profitability was high. With the financial capacity to cover relocation costs (Caves, 1996), these firms have the ability to delocalize production and optimize production across multiple sites.

In conclusion, the size of a firm can be viewed as a proxy for the level of sunk capital cost, with larger firms being less likely to relocate due to the associated moving costs and smaller firms more likely to do so due to lower capital investments and a greater tendency to make repeated small adjustments.•
Hypothesis 1a: Larger firms are more inclined to engage in delocalization and potentially relocate a portion of their operations internationally.•

Hypothesis 1b: The magnitude of sunk assets is expected to have a detrimental impact on the likelihood of delocalization.*Multinationality*

Multinational firms are more likely to have an advantage over non-multinational firms when it comes to location selection. Their involvement in global supply chains and greater integration into these chains enables them to overcome the challenges and costs associated with international expansion, as opposed to a non-multinational firm which would likely be entering a new international market for the first time.Relocation costs are often lower for multinational firms due to their expertise in operating across borders (Pennings and Sleuwaegen, 2000). These firms have a proven track record of successful international investment, making them more likely to quickly relocate. Additionally, drawing from the perspective of behavioral location theory, multinational firms are more likely to have access to a greater amount of information, which could increase their mobility and reduce their attachment to traditional, known locations (Konings and Murphy, 2006).

In conclusion, the existence of global supply chains and experience in operating across borders make multinational firms better equipped to handle the challenges and costs of international relocation compared to non-multinational firms, who may be entering their first international market.

•Hypothesis 2: Firms that are part of a multinational group are more prone to engage in delocalization.

Ownership

The ownership structure of a firm has been found to have an impact on its willingness to relocate. Companies can either be owned domestically or by a foreign parent, with domestic firms also having the potential to be multinational.

Research by Dunning (1993) suggests that foreign-controlled firms are more likely to consider international relocation than their domestic counterparts. Mata and Freitas (2012) further support this finding by revealing that foreign-owned multinationals in Portugal were more likely to relocate as the firm aged. These results point to the belief that foreign-controlled firms have unique management advantages, as a result of their international ownership, which enables them to transfer assets and knowledge across borders in an effort to optimize profitability (Pennings and Sleuwaegen, 2000).

In conclusion, the ownership structure of a firm has been shown to influence its tendency to relocate. Foreign-controlled firms have been found to be quicker to consider international relocation compared to domestic firms, with research suggesting that foreign ownership offers unique management advantages that can be leveraged to enhance profitability.

•Hypothesis 3: Foreign-controlled firms are more likely to engage in delocalization.

•Hypothesis 4: Firms with foreign capital are also more susceptible to delocalization and may consider international relocation.

Internal Growth

Brouwer et al. (2004) suggest that the spatial adjustment process to firm growth in relation to the external environment is a crucial factor in explaining firm relocation through the lens of institutional theory. The hypothesis posits that firms strive to operate at their optimal staffing levels. However, internal growth, whether positive or negative, may cause a deviation from this optimum, leading to the need for relocation to a larger facility. This may occur in the absence of additional land in the immediate vicinity and may require a move to a different location (Kronenberg, 2013).

Internal growth may also serve as an indicator of spatial adjustments that have been triggered by exogenous factors, such as changes in supply conditions or mergers and acquisitions. Regardless of the trigger, these factors may still necessitate a firm to consider relocating due to internal growth changes (van Vilsteren and Wever, 1999).

•Hypothesis 5. the hypothesis proposes that internal growth, regardless of its direction, leads to delocalization and the potential for relocation.

Sector and Salary

According to literature, firms that rely on low-skilled labor and are exposed to high average wages are more likely to relocate to a lower-cost jurisdiction. On the other hand, high-skilled companies paying higher wages are less likely to consider relocation. The hypothesis proposes that firms paying higher than average wages for their sector will consider relocating to a different location with improved profitability.

•Hypothesis 6: Manufacturing firms paying high salaries are also likely to delocalize and potentially relocate abroad with a greater likelihood.

4. Data Sources and Limitations

The "Manufacturing Firms Relocation" dataset was developed in-house by the Ontario Ministry of Finance (MOF). The sample of firms included in the dataset was obtained by merging data from various sources, including corporate income tax, payroll, and other tax administration data, related to corporations operating in Ontario for the years 2003 to 2015. Access to this data was facilitated through agreements between the MOF and the Canada Revenue Agency.

The dataset includes corporations that claimed the Ontario Manufacturing and Processing Credit/Deduction or reported a NAICS code (North American Industry Classification System) with the first two digits of 31, 32, and 33 at least once during a thirteen-year period. To protect the confidentiality of the data, a company identifier was created by assigning each nine-digit business number a unique random number. This identifier was used to keep track of the same company across multiple years.

To ensure the quality of the data, small firms were excluded from the sample when applying the Random Forest (RF) method. Any firm averaging fewer than four statements of remuneration (T4 income tax slips) across the entire sample was removed. This step was taken to eliminate spurious start-ups and exits resulting from reorganizations, mergers and acquisitions, or other factors.

The figures derived from the Manufacturing Firms Relocation dataset may not be directly comparable to data reported by other agencies, such as Statistics Canada, due to differences in scope and methodology. This dataset focuses specifically on corporations, while other sources may report on a wider range of enterprise types, including companies and business establishments. Despite these limitations, the dataset still contains a substantial amount of information, with a total of 468,961 observations and 1,286 firms (1.2%) that exited the market between 2003 and 2015.

However, it is important to note that there are limitations to the external validity of the data, as the availability of information on manufacturing firms that have relocated may be limited. Additionally, there may be potential confounding factors that are not accounted for in the analysis, which could lead to biased interpretations of the results.

Despite these limitations, the availability of information on foreign parent corporations, foreign subsidiaries, foreign associated corporations, and foreign-related corporations provides valuable insights into the impact of ownership nationality on the likelihood of delocalization.

5. Methodology and Research Design

The Empirical Model

The delocalization decision of firms was modeled using a logistic regression approach. This model aimed to establish the relationship between the probability of a firm to delocalize and a set of explanatory variables. The model was based on the premise of Neoclassical Location Theory, which posits that firms choose locations that maximize their profits. Therefore, if a firm decided to stay in its current location, it was assumed that this location offered the most benefits.

The probability of delocalization (1 for exit, 0 otherwise) was calculated for each observation using the following equation:

$$Ei = \alpha Br + \beta Yi + \varepsilon i$$

where Br and Yi represented firm- and region-specific characteristics, respectively. Location-specific characteristics that were common among all firms, such as population density, were also included in the model. However, since the constant value was deemed unessential, it was omitted from the analysis. The average wage in the firm's sector was also added, with the value being sector-specific.

While the distance of each municipality to a firm's region of origin could have been determined, it was deemed unfeasible to do so without having data on firms relocating from each municipality and sector. As a result, distance to origin was excluded from the analysis.

In addition to the logistic regression model, a random forest model was also used to evaluate the factors that influenced a firm's decision-making process in choosing the optimal location. Descriptive statistics and definitions of the explanatory variables are provided in Tables 1 and 2. The definition of the explanatory variables, as well as descriptive statistics, are presented in Table 1 and Table 2. A firm was considered to have "exited" the market when a decrease in the number of employees by at least two, which brought the firm to less than five employees, was observed.

Table 1. The list of field names in the MFR dataset

Field Name	Description
YEAR	*Calendar Year*
NEW_ID	*Anonymous Company identifier*
OAF	*Ontario Allocation Factor*
TYPE_CORP	*Type of corporation*
FSA_HEAD_OFFICE	*Forward Sortation Area of the Head Office*
AGE	*Age of a firm since the year of*
NAICS	*North America Industry Classification*
MPP_CR	*Manufacturing and Processing Credit*
LAND	*The value of land owned by a corporation*
DEPL_ASSETS	*Depletable assets*
AMM_DEPL_ASSET	*Accumulated amortization of depletable*
BUILDINGS	*Buildings*
AMM_BUILDINGS	*Accumulated amortization of buildings*
MACHINERY	*Machinery, equipment, furniture, and*
AMM_MACHINERY	*Accumulated amortization of machinery, equipment, furniture, and fixtures*
OTHER_TAN_CAP_	*Other tangible capital assets*
AMM_OTHER_TAN	*Accumulated amortization of other*
TOT_TANG_ASSET	*Total tangible capital assets*
AMM_TOT_TANG_	*Accumulated amortization of total tangible*
NUM_EMP	*Number of employees*
AVE_WAGE	*Average wage*

Table 2. Descriptive Statistics

Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
YEAR	468,961	2,009.0	3.7	2,003	2,006	2,012	2,015
NEW_ID	468,961	27,905.1	15,550.7	1,000	14,424	41,384	54,899
OAF	439,818	1.0	0.1	0.0	1.0	1.0	1.0
TYPE_CORP	468,961	1.2	0.6	1	1	1	5
AGE	468,961	15.5	12.6	-2	6	22	142
NAICS	444,250	346,750.7	78,691.2	111,110.0	323,119.0	337,123.0	914,110.0
MPP_CR	468,961	4,383.3	139,830.9	0	0	0	54,091,079
LAND	468,961	163,196.5	7,547,335.0	-663,312	0	0	2,534,733,000
DEPL_ASSETS	468,961	133,019.1	16,989,725.0	-198,781	0	0	4,737,647,140
AMM_DEPL_ASSETS	468,961	-64,988.8	10,473,044.0	-3,362,005,326	0	0	116,959
BUILDINGS	468,961	816,907.6	17,799,688.0	-6,632,355	0	0	3,227,122,425
AMM_BUILDINGS	468,961	-334,450.9	9,207,350.0	-2,236,531,951	0	0	14,546,430
MACHINERY	468,961	3,261,499.0	80,018,710.0	-3,493,673	0	112,796	17,323,815,000
AMM_MACHINERY	468,961	-1,837,882.0	42,617,303.0	-7,372,021,157	-59,668	0	28,265,250
OTHER_TAN_CAP_ASSETS	468,961	1,300,560.0	93,773,299.0	-82,738,860	0	0	25,653,422,461
AMM_OTHER_TAN_CAP_ASSETS	468,961	-478,909.2	31,874,262.0	-9,604,409,452	0	0	47,202,236
TOT_TANG_ASSETS	468,961	7,856,071.0	165,850,363.0	-2,923,991	965	702,320	30,391,069,601
AMM_TOT_TANG_ASSETS	468,961	-3,753,644.0	72,251,835.0	-12,966,414,778	-351,312	0	142,594,858
NUM_EMP	295,292	50.9	309.6	1.0	3.0	28.0	23,215.0
AVE_WAGE	295,292	37,027.3	67,157.9	0.0	18,923.3	45,741.5	15,692,500.0
ForeignParentCount	196,942	0.1	0.3	0.0	0.0	0.0	6.0
ForeignSubsCount	196,942	0.1	0.9	0.0	0.0	0.0	78.0
ForeignAssocCount	196,942	0.8	5.0	0.0	0.0	0.0	435.0
ForeignRelCount	196,942	0.1	3.9	0.0	0.0	0.0	484.0
ForeignParent	196,942	0.1	0.3	0.0	0.0	0.0	1.0
ForeignSubs	196,942	0.05	0.2	0.0	0.0	0.0	1.0
ForeignAssoc	196,942	0.1	0.3	0.0	0.0	0.0	1.0
ForeignRel	196,942	0.02	0.1	0.0	0.0	0.0	1.0

A Generalized Model

The hypotheses were tested through the implementation of a logistic regression model. The model aimed to examine the relationship between the probability of delocalization and a set of explanatory variables. The dependent variable, Exit, was defined as the occurrence of delocalization, which was represented as 1, or otherwise 0. The independent variables, which included firm- and region-specific characteristics, were:

$$Exit_{it}=a+b*age_{it}+c*Sunk_{it}+d*Typecorp_{it}+e*Foreignsubcount_{it}+f*Avewage_{it}+g*Foreginparentcount_{it}+H*Intgrow_{it}+I*Size_{it}+error\text{-}it$$

Age: controlled for as a baseline variable.

Size: the natural logarithm of the number of employees, which represents the size of the firm.

Sunk: the ratio of sunk tangible assets to total assets, which served as a proxy for the degree of investment sunk cost.

ForeignParentCount and *ForeignSubCount*: dummy variables, which were set to 1 if the firm had a foreign parent company or was a subsidiary of a foreign country, respectively, and 0 otherwise.

Typecorpit: a categorical variable, which represented the type of corporation as reported on the T2 corporate income tax return. The types of corporation were defined as follows (as described in Table 3):

Table 3. Type of corporation description

Type of corporation	**Type of corporation description**
1	CCPC
2	Other private corporation
3	Public corporation
4	Corporation controlled by a public corporation
5	Other corporation

Avewageit: the natural logarithm of the average wage of employees within the firm, which was calculated as the sum of the T4 Payroll, Canada Pension Plan, Employment Insurance and Employer Health Tax paid by the corporation divided by the number of employees.

Intgrowit: a dummy variable, which served as a proxy for internal growth and measured the positive (1) or negative (0) growth in the number of employees in the two years preceding the observational year (as a change in the natural logarithm of the firm's number of employees).

Methodology

The study utilized both panel data and two machine learning algorithms, artificial neural networks (ANN) and random forests (RF), to estimate the probability of firm exit based on the characteristics of similar firms that have already exited the market.

The present study employs a machine learning approach to predict the likelihood of firms exiting the market. Machine learning is a branch of artificial intelligence that leverages statistical techniques to enable computers to learn from data and make predictions. The study is considered a supervised learning problem as it primarily focuses on prediction and the possible values for the target or response variable are specified with known training cases. In this case, the target variable is the binary classification of firm exit, with values either 0 or 1. The inputs used to make the predictions, also referred to as predictors or covariates, include firm size, age, ownership, and other relevant characteristics.

Logit model

Initially, the examination of panel data or pooling data was performed using the F Limer test. This test considered the null hypothesis of "pooling" and the alternative hypothesis of "panel data". The use of panel data allows for the control of variables that cannot be observed or measured, such as cultural factors, differences in business practices across companies, or variables that change over time but not across entities, such as national policies, federal regulations, and international agreements. This accounts for individual heterogeneity.

The random effects assumption, as made in a random effects model, stipulates that the individual-specific effects are uncorrelated with the independent variables, while the fixed effect assumption posits that the individual-specific effects are correlated with the independent variables. If the random effects assumption holds, the random effects model is more efficient than the fixed effects model. However, if the assumption does not hold, the random effects model is inconsistent.

The statistical results of the F Limer test confirmed the use of panel data. The Hausman test, with a quantity of 10.27 and a confidence level of 99 percent, resulted in the selection of the random effect pattern.

After testing different model specifications, the final model was formulated as:

Exitit=a+bageit+cSunkit+dTypecorpit+fAvewageit+iSizeit+errorit.

Random Forest Decision Trees (RFDT)

The dataset consisted of 88,754 firms, with 951 firms (0.01%) exiting the market between 2004 and 2014. To facilitate the analysis, the dataset was cleaned, with only the years 2013 and 2014 being examined and firms with less than four employees being removed. A bootstrap method was used to select the sample dataset for model development, with 80% of the data randomly assigned to a training set and 20% set aside for model testing. The models were trained using 5-fold cross-validation.

The results indicated that the random forest-based decision tree (DT) model outperformed the artificial neural network with a higher prediction accuracy of 81% compared to 68%. The study also employed support vector machines (SVM) and k-nearest neighbor (k-NN) algorithms for the classification of firms who choose to leave the market, utilizing both push and pull variables from 80% of the sample data. SVM is a discriminative classifier that outputs an optimal hyperplane to categorize new examples, while k-NN algorithms use a database of previously separated classes to predict the classification of new sample points. These machine learning methods provided a comprehensive approach to analyze the firm exit problem and have the potential to inform policy and decision-making in related domains."

6. Findings and Implications

The Estimation Results of the Logit Model

A random-effects logistic regression was performed to investigate the factors influencing firm turnover behavior, utilizing a sample of 458,976 observations and 53,530 groups. The random effects were modeled using a Gaussian distribution, with a minimum of 1 observation per group, an average of 8.6 observations per group, and a maximum of 13 observations per group. The mvaghermite integration method was utilized, with 12 integration points, and the fit of the model was found to be statistically significant, as indicated by the Wald chi-square test (log-likelihood = -130,402.83, chi-square statistic = 66,806.16, $p < 0.0000$).

The logit model results, presented in Table 4, align with existing literature and hypotheses. The analysis suggests that firms with higher salaries and sunk costs have a greater likelihood of exiting, while those with higher firm age are more likely to persist in the market.

The results reveal that several variables had a significant impact on firm turnover behavior.

The age of a firm was found to have a statistically significant and negative impact on the firm's decision to exit. This means that older firms have a relatively low probability of exit and therefore, age serves as a key predictor of a firm's market presence.

Moreover, the number of employees of a firm plays an important role in determining firm exit as manufacturing firms heavily rely on labor and are sensitive to the wages paid. The results suggest that higher salaries, relative to other regions, increase the overall likelihood of firm exit.

The logarithm wage per employee was found to have a statistically significant and positive effect on the decision to exit. This finding aligns with Murphy et al. (2006), who found that multinational enterprises are more likely to relocate to low-wage regions using a firm-level panel data set of over 1,000 European multinational parent enterprises and their European affiliates.

The sunk cost coefficient was found to have a statistically significant and negative effect on the decision to exit for manufacturing firms. This means that firms with higher sunk costs have a relatively lower probability of exit and the probability of staying increases by 2.9 if the sunk cost increases by one unit. The sunk cost can be considered a location-specific advantage as the loss of these investments is likely to have a negative impact on the performance of a relocating firm. Larger firms may have the ability to delocalize their production and shift it across multiple optimal production sites to maximize their profits in the long term, which could result in the sunk cost having a positive effect on a firm's location or exit decisions.

Ownership was also found to influence a firm's exit decision. Canadian-controlled private corporations were found to have a decreased probability of exiting the market, while the other three ownership types (other private corporation, public corporation, and corporation controlled by a public corporation) had negative and significant effects on a firm's exit decision.

Additionally, the Ontario Allocation Factor (OAF) was found to have a negative and significant effect on a firm's exit decision. The OAF signals the extent to which a firm derives its taxable income from Ontario and if a firm derives most of its income from Ontario, it would be difficult to leave the province as it would potentially lose most of its income generation.

Table 4. Logit Model Results

```
Random-effects logistic regression              Number of obs     =    458,976
Group variable: ID                              Number of groups  =     53,530

Random effects u_i ~ Gaussian                   Obs per group:
                                                              min =          1
                                                              avg =        8.6
                                                              max =         13

Integration method: mvaghermite                 Integration pts.  =         12
                                                Wald chi2(8)      =   66806.16
Log likelihood  = -130402.83                    Prob > chi2       =     0.0000
```

exitf	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnwageper	2.390648	.0092799	257.62	0.000	2.372459	2.408836
lnsunk	.0328831	.0068858	4.78	0.000	.0193872	.046379
lnage	-.2926406	.009242	-31.66	0.000	-.3107545	-.2745267
oaf	.4325827	.0644502	6.71	0.000	.3062625	.5589029
pubcorp	-1.099836	.2080114	-5.29	0.000	-1.507531	-.6921411
privatecorp	-.7178759	.1192087	-6.02	0.000	-.9515207	-.4842312
ccpc	.4598149	.1111186	4.14	0.000	.2420264	.6776034
controlledbypub	-.39534	.1363512	-2.90	0.004	-.6625834	-.1280966
_cons	-20.8365	.1490667	-139.78	0.000	-21.12866	-20.54433
/lnsig2u	1.357612	.0126526			1.332813	1.38241
sigma_u	1.971522	.0124724			1.947227	1.99612

The estimation results of Random Forest Decision Trees (RFDT)

The results of the Random Forest Decision Trees (RFDT) estimation were analyzed and compared to other algorithms. The findings indicated that the RF algorithm was the most effective in modeling the turnover behavior of firms. The most significant predictors were found to be the number of employees and the average wage. The study revealed that positive internal growth within the workforce leads to an increase in the likelihood of firm exit. Furthermore, it was observed that firms with foreign parent companies are more likely to exit and potentially relocate to another country. The performance of each model was evaluated based on the training and test accuracy, as presented in Table 5. However, it should be noted that the accuracy of the models may be limited due to the imbalance in the distribution of exits, particularly by larger companies, in the dataset. A higher kappa value indicates a more accurate prediction model.

This confusion matrix provides the evaluation of a predictive model aimed at identifying the turnover behavior of firms. The model has been tested on a sample of 2,225 observations and has made predictions for two classes: 0 (no turnover) and 1 (turnover).

The entries in the matrix are the number of true positive (TP), false positive (FP), false negative (FN), and true negative (TN) predictions. In this case, the matrix shows:

- 1857 observations were correctly classified as class "0"
- 20 observations were correctly classified as class "1"
- 294 observations were falsely classified as class "1"
- 2 observations were falsely classified as class "0"

The accuracy of the model is reported to be 0.8638, with a 95% confidence interval of (0.8486, 0.8779). This indicates that the model correctly classifies 86.38% of the observations. The No Information Rate (the accuracy achieved by always predicting the most frequent class) is reported to be 0.9899, with a p-value of 1, indicating that the model is significantly better than the baseline.
The Kappa statistic, which measures the agreement between the model's predictions and the actual class labels, is reported to be 0.1021. The McNemar's test, which assesses the significance of the difference between the two sets of predictions (model and actual), has a p-value less than 2e-16, indicating a significant difference between the two sets of predictions.
The sensitivity of the model, also known as the True Positive Rate, is reported to be 0.86332, indicating that the model correctly identifies 86.33% of the positive cases (i.e., turnover). The specificity of the model, also known as the True Negative Rate, is reported to be 0.90909, indicating that the model correctly identifies 90.91% of the negative cases (i.e., no turnover).
The Positive Predictive Value (PPV), also known as the Precision, is reported to be 0.99892, indicating that 99.89% of the positive predictions made by the model are actually positive. The Negative Predictive Value (NPV), is reported to be 0.06369, indicating that only 6.37% of the negative predictions made by the model are actually negative.
Finally, the prevalence of the positive class (turnover) is reported to be 0.98988, and the detection rate is reported to be 0.85458. The detection prevalence is reported to be 0.85550, and the balanced accuracy of the model is reported to be 0.88621.

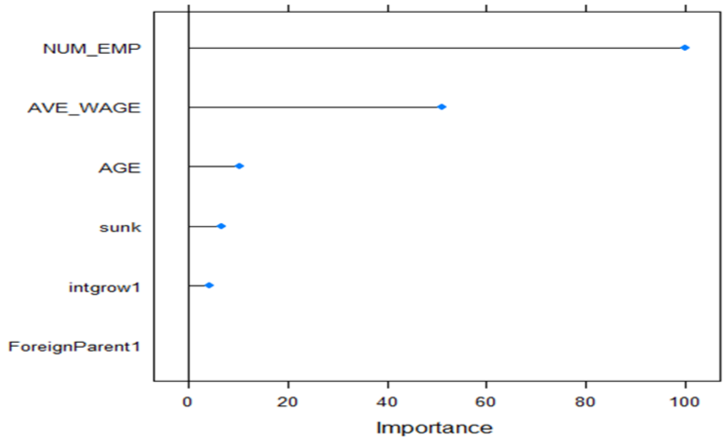
Table 5. Confusion Matrix and Statistics

```
Reference
Prediction    0    1
0 1857    2
1  294   20

Accuracy : 0.8638
95% CI : (0.8486, 0.8779)
No Information Rate : 0.9899
P-Value [Acc > NIR] : 1

Kappa : 0.1021
Mcnemar's Test P-Value : <2e-16

Sensitivity : 0.86332
Specificity : 0.90909
Pos Pred Value : 0.99892
Neg Pred Value : 0.06369
Prevalence : 0.98988
Detection Rate : 0.85458
Detection Prevalence : 0.85550
Balanced Accuracy : 0.88621

'Positive' Class : 0
```

The importance chart in Random Forest Decision Trees (RFDT) provides a quantitative evaluation of the features used in the model, indicating their relative importance for making accurate predictions. The chart provides a visual representation of the features' contribution to the performance of the RFDT model and is a valuable tool for identifying the most relevant features for making predictions.

The interpretation of the importance chart in RFDT is based on the average decrease in impurity of each feature across all the trees in the forest. The decrease in impurity is a measure of how much each feature contributes to reducing the variance of the model's predictions. The higher the decrease in impurity, the more important the feature is considered to be.

The importance chart in RFDT is a crucial component in the process of refining and optimizing RFDT models. By identifying the most important features, analysts can focus their efforts on improving these features, which can result in improved model performance. Additionally, by reducing the number of features and eliminating redundant or irrelevant features, the chart can help to reduce the risk of overfitting and improve computational efficiency.



The results of the study indicate that the key determinants of a firm's turnover behavior, as indicated by a Random Forest Decision Tree (RFDT) Importance Chart, are the combination of employment size and average wage, the total value of tangible assets, the age of the firm, and the nationality-foreign control aspect. These variables were found to be the most significant predictors of firm turnover behavior, as reflected by their high relative importance scores on the RFDT Importance Chart.

The RFDT Importance Chart provides a visual representation of the contribution of each variable to the performance of the RFDT model, enabling analysts to identify the most important factors affecting firm turnover behavior. By evaluating the relative importance of each variable, the chart provides valuable insights into the drivers of firm turnover and helps guide decision making for further analysis and optimization of the model.

7. Conclusion

In conclusion, this study provides an in-depth examination of the phenomenon of delocalization and its impact on firms, sectors, regions, and countries. The research objectives were to analyze firm-specific factors driving the decision to delocalize, and the study contributes to the existing literature in several ways. Firstly, the study offers a comprehensive understanding of the firm's decision-making process by exploring the dynamic nature of delocalization. Secondly, the study employs a novel methodology - the random forest decision tree method - for modeling the turnover behavior of firms.

The data used in the study was sourced from the Ontario Ministry of Finance and was analyzed through a combination of descriptive statistics, logistic regression modeling, and nonparametric techniques. The results of the logistic regression model indicated that the most important factors affecting firm turnover behavior were employment size, average wage, total tangible assets, firm age, and nationality-foreign control. The results showed that older firms with a higher sunk cost have a lower probability of exit, and larger firms may have the ability to delocalize when their profitability is high and variable costs are low.

The superior prediction accuracy of the random forest decision tree model highlights the importance of considering firm-level factors when analyzing the decision to delocalize. In conclusion, the results support the hypothesis that a firm's turnover behavior is mostly determined by its own characteristics such as size and age.

The results of the study provide valuable insights for business decision-makers and government subsidy providers to assess the incrementality and need for government support. In Ontario, there is a need to promote business growth as larger businesses tend to have a greater impact on GDP and job creation.

The ongoing COVID-19 pandemic has further exacerbated the challenges faced by businesses in Ontario, including labour shortages, financial losses, barriers to accessing new customers, and closures. The increased competition in a globalized economy has put pressure on firms to consider relocating operations to lower-cost jurisdictions. The results of the study suggest that firm-level characteristics play a crucial role in the decision to delocalize, and the random forest decision tree method is a suitable approach to model this behavior. To retain businesses and maintain a strong manufacturing sector in Ontario post-pandemic, the government may consider creating a supportive environment, providing access to recovery funds, promoting remote work and digital transformation, supporting workforce retraining, and fostering collaboration and innovation.

8. Further research

Further research that would be of benefit to policymakers overseeing business subsidy programs would involve a more in-depth examination of the "pull" factors that influence firm relocation decisions. An analysis of firms that have relocated or are in the process of relocating would provide valuable insight into why they chose to move and where they are headed, enabling better targeting of business subsidy programs and more efficient allocation of resources to those sectors that require it. The models analyzed in this study serve as a starting point for using machine learning to predict firm delocalization. With an increase in the number of observations of firm exits and the incorporation of additional variables (such as other sectors beyond manufacturing), these models have the potential to become more practical for real-world use.

APPENDIX A: PAIRWISE CORRELATION COEFFICIENTS BETWEEN THE VARIABLES

Pairwise correlation coefficients are measures of the relationship or association between two variables. The most commonly used correlation coefficient is Pearson's correlation coefficient, which ranges from -1 to 1 and measures the strength and direction of the linear relationship between two variables. A value of -1 indicates a perfect negative correlation, a value of 1 indicates a perfect positive correlation, and a value of 0 indicates no correlation.

	exit	Foreig~l	Foreig~c	Fore~ent	F~lCount	F~cCount	F~sCount
exit	1.0000						
ForeignRel	-0.0129*	1.0000					
	0.0000						
ForeignAssoc	-0.0493*	0.0648*	1.0000				
	0.0000	0.0000					
ForeignP~ent	-0.0197*	0.1172*	0.3828*	1.0000			
	0.0000	0.0000	0.0000				
ForeignRel~t	-0.0046*	0.2105*	0.0107*	0.0304*	1.0000		
	0.0414	0.0000	0.0000	0.0000			
ForeignAss~t	-0.0239*	0.0273*	0.4082*	0.1686*	0.0030	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.1865		
ForeignSub~t	-0.0181*	0.0281*	0.1283*	0.0487*	0.0155*	0.1176*	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
ForeignP~unt	-0.0200*	0.1118*	0.3665*	0.9467*	0.0293*	0.1741*	0.0558*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AVE_WAGE	-0.0017	0.0071*	0.0527*	0.0556*	0.0046	0.0308*	0.0382*
	0.3467	0.0083	0.0000	0.0000	0.0830	0.0000	0.0000
NUM_EMP	-0.0792*	0.0268*	0.1251*	0.1013*	0.0061*	0.0902*	0.1538*
	0.0000	0.0000	0.0000	0.0000	0.0224	0.0000	0.0000

```
             |
AMM_TOT_TA~S |     0.0179* -0.0393* -0.0825* -0.0522*
-0.0055* -0.0695* -0.1430*
             |     0.0000   0.0000   0.0000   0.0000
0.0148   0.0000   0.0000
             |
TOT_TANG_A~S |   -0.0162*   0.0409*   0.0814*   0.0454*
0.0045*   0.0751*  0.1620*
             |     0.0000   0.0000   0.0000   0.0000
0.0464   0.0000   0.0000
             |
AMM_OTHER_~S |     0.0055* -0.0335* -0.0327* -0.0211*
-0.0030  -0.0335* -0.1124*
             |     0.0002   0.0000   0.0000   0.0000
0.1787   0.0000   0.0000
             |
OTHER_TAN_~S |   -0.0051*   0.0399*   0.0286*   0.0172*
0.0029   0.0318*  0.1057*
             |     0.0005   0.0000   0.0000   0.0000
0.2025   0.0000   0.0000
             |
AMM_MACHIN~Y |     0.0149* -0.0317* -0.0627* -0.0449*
-0.0056* -0.0567* -0.0965*
             |     0.0000   0.0000   0.0000   0.0000
0.0125   0.0000   0.0000
             |
    MACHINERY |   -0.0138*   0.0234*   0.0629*   0.0417*
0.0042   0.0645*  0.1188*
             |     0.0000   0.0000   0.0000   0.0000
0.0648   0.0000   0.0000
             |
AMM_BUILDI~S |     0.0126* -0.0320* -0.0595* -0.0480*
-0.0055* -0.0519* -0.1045*
             |     0.0000   0.0000   0.0000   0.0000
0.0146   0.0000   0.0000
             |
    BUILDINGS |   -0.0158*   0.0322*   0.0750*   0.0587*
0.0064*   0.0582*  0.1015*
             |     0.0000   0.0000   0.0000   0.0000
0.0047   0.0000   0.0000
             |
AMM_DEPL_A~S |     0.0022   -0.0072* -0.0178* -0.0011
-0.0001  -0.0283* -0.0733*
             |     0.1238   0.0014   0.0000   0.6152
0.9600   0.0000   0.0000
             |
         LAND |   -0.0066*   0.0103*   0.0363*   0.0168*
0.0020   0.0161*  0.0250*
             |     0.0000   0.0000   0.0000   0.0000
0.3692   0.0000   0.0000
             |
  DEPL_ASSETS |   -0.0024     0.0057*   0.0175*   0.0038
-0.0000   0.0330*  0.0976*
             |     0.1037   0.0120   0.0000   0.0951
0.9997   0.0000   0.0000
             |
         LAND |   -0.0066*   0.0103*   0.0363*   0.0168*
0.0020   0.0161*  0.0250*
```

```
                 |   0.0000    0.0000    0.0000    0.0000
0.3692   0.0000   0.0000
              |
        MPP_CR |   -0.0113*   0.0116*   0.0525*   0.0427*
0.0125*  0.0481*  0.1072*
                 |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
              |
            AGE |   -0.0058*   0.0129*   0.0150*   0.0124*
0.0068*  0.0347*  0.0313*
                 |   0.0001    0.0000    0.0000    0.0000
0.0026   0.0000   0.0000
              |
    TYPE_CORP |   -0.0537*   0.0892*   0.3767*   0.4272*
0.0356*  0.2502*  0.1481*
                 |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
              |
            OAF |    0.0141* -0.0531* -0.2246* -0.1813*
-0.0430* -0.1227* -0.1267*
                 |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
              |

                 | F~tCount AVE_WAGE   NUM_EMP AMM_TO~S
TOT_TA~S AMM_OT~S OTHER_~S
-   -   -   -   -   -   -   -   -   -   -   -   -
+---------------------------------------------------
---------
ForeignP~unt |   1.0000
              |
              |
    AVE_WAGE |   0.0543*  1.0000
              |   0.0000
              |
     NUM_EMP |   0.1076*  0.0225*  1.0000
              |   0.0000   0.0000
              |
AMM_TOT_TA~S |  -0.0617* -0.0281* -0.4516*  1.0000
              |   0.0000   0.0000   0.0000
              |
TOT_TANG_A~S |     0.0551*    0.0293*    0.4276*  -0.9014*
1.0000
              |   0.0000   0.0000   0.0000   0.0000
              |
AMM_OTHER_~S |    -0.0271*  -0.0121*  -0.1365*    0.4816*
-0.5534*  1.0000
                 |   0.0000    0.0000    0.0000    0.0000
0.0000
              |
OTHER_TAN_~S |     0.0258*    0.0121*    0.1229*  -0.4366*
0.5902* -0.9100*  1.0000
                 |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000
              |
AMM_MACHIN~Y |    -0.0539*  -0.0217*  -0.3639*    0.7259*
-0.5952*  0.0034* -0.0051*
```

```
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0217   0.0004
             |
   MACHINERY |   0.0480*   0.0214*   0.3745*  -0.6553*
0.6307* -0.0116*  0.0053*
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0003
             |
AMM_BUILDI~S |  -0.0529*  -0.0173*  -0.4433*   0.5177*
-0.3780*  0.0023  -0.0028
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.1163   0.0563
             |
   BUILDINGS |   0.0665*   0.0202*   0.4954*  -0.5432*
0.4208* -0.0172*  0.0031*
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0322
             |
AMM_DEPL_A~S |  -0.0039   -0.0059*  -0.0457*   0.2674*
-0.2227*  0.2579* -0.2165*
             |   0.0857    0.0013    0.0000    0.0000
0.0000   0.0000   0.0000
             |
        LAND |   0.0186*   0.0065*   0.1446*  -0.1025*
0.1278* -0.0067*  0.0021
             |   0.0000    0.0004    0.0000    0.0000
0.0000   0.0000   0.1595
             |
 DEPL_ASSETS |   0.0091*   0.0121*   0.0509*  -0.2710*
0.2321* -0.2861*  0.2088*
             |   0.0001    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
             |
        LAND |   0.0186*   0.0065*   0.1446*  -0.1025*
0.1278* -0.0067*  0.0021
             |   0.0000    0.0004    0.0000    0.0000
0.0000   0.0000   0.1595
             |
      MPP_CR |   0.0455*   0.0174*   0.2718*  -0.1840*
0.1529* -0.0453*  0.0219*
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
             |
         AGE |   0.0145*   0.0587*   0.0598*  -0.0542*
0.0467* -0.0282*  0.0265*
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
             |
   TYPE_CORP |   0.4050*   0.1036*   0.1879*  -0.0996*
0.0964* -0.0336*  0.0310*
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
             |
         OAF |  -0.1751*  -0.0664*  -0.1119*   0.1213*
-0.1222*  0.0345* -0.0363*
             |   0.0000    0.0000    0.0000    0.0000
0.0000   0.0000   0.0000
             |
```

	AMM_MA~Y	MACHIN~Y	AMM_BU~S	BUILDI~S	AMM_DE~S	LAND	DEPL_A~S
AMM_MACHIN~Y	1.0000						
MACHINERY	-0.9096*	1.0000					
	0.0000						
AMM_BUILDI~S	0.4702*	-0.3507*	1.0000				
	0.0000	0.0000					
BUILDINGS	-0.5020*	0.4032*	-0.9116*	1.0000			
	0.0000	0.0000	0.0000				
AMM_DEPL_A~S	0.0074*	-0.0065*	0.0004	-0.0002	1.0000		
	0.0000	0.0000	0.7855	0.8750			
LAND	-0.1009*	0.0907*	-0.1341*	0.1676*	-0.0067*	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0000		
DEPL_ASSETS	-0.0152*	0.0140*	-0.0006	0.0008	-0.9046*	0.0061*	1.0000
	0.0000	0.0000	0.7001	0.5769	0.0000	0.0000	
LAND	-0.1009*	0.0907*	-0.1341*	0.1676*	-0.0067*	1.0000*	0.0061*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MPP_CR	-0.1363*	0.1375*	-0.2674*	0.2807*	-0.0137*	0.0478*	0.0289*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AGE	-0.0306*	0.0240*	-0.0368*	0.0415*	-0.0081*	0.0130*	0.0099*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TYPE_CORP	-0.0877*	0.0883*	-0.0658*	0.0811*	-0.0206*	0.0314*	0.0253*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OAF	0.0975*	-0.0989*	0.0775*	-0.1003*	0.0216*	-0.0516*	-0.0280*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

```
                 |       LAND    MPP_CR        AGE  TYPE_C~P
OAF
-    -    -    -    -    -    -    -    -    -    -    -    -
+-------------------------------------------------
        LAND |   1.0000
             |
             |
      MPP_CR |   0.0478*  1.0000
             |   0.0000
             |
         AGE |   0.0130*  0.0187*  1.0000
             |   0.0000   0.0000
             |
   TYPE_CORP |   0.0314*  0.0576*  0.0534*  1.0000
             |   0.0000   0.0000   0.0000
             |
                 OAF |   -0.0516* -0.0316* -0.0767* -0.2652*
1.0000
             |   0.0000   0.0000   0.0000   0.0000
             |
```

The "*" next to the correlation coefficients indicates that the correlation is statistically significant, meaning that it is unlikely to have occurred by chance. The p-values are not shown in this chart, but they are usually used to determine statistical significance.

In this chart, you can see that there are positive and negative correlations between various variables. The strength of the correlation depends on the magnitude of the coefficient, with larger magnitudes indicating stronger correlations.

Testing model specification

In the present study, a model specification test, known as the linktest, was conducted to determine the adequacy of the model's structure. The aim of the linktest was to assess the need for additional variables in the model by conducting a regression analysis of the observed Y variable against Yhat (or Xβ) and Yhat-squared as independent variables.

The results of the linktest were analyzed by examining the significance of the variable _hatsq. The null hypothesis stated that there was no specification error in the model. If the p-value associated with _hatsq was found to be significant, it would indicate that the null hypothesis could not be rejected, and it could be concluded that the model was correctly specified.

```
Logistic regression                             Number of obs     =    295,292
                                                LR chi2(2)        =  162397.17
                                                Prob > chi2       =     0.0000
Log likelihood = -67636.483                     Pseudo R2         =     0.5456

------------------------------------------------------------------------------
        exit |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        _hat |   .5549409   .0078114    71.04   0.000     .5396308    .5702509
      _hatsq |   -.934513   .0096377   -96.96   0.000    -.9534024   -.9156235
       _cons |   .8346046   .0098713    84.55   0.000     .8152571    .8539521
------------------------------------------------------------------------------
```

This output is from a logistic regression model, which is used to model the relationship between a binary outcome variable and one or more predictor variables. The model estimates the probability of the outcome variable taking on a value of 1 given the values of the predictor variables.

The number of observations (295,292) is the number of records used in the analysis. The LR chi2 statistic of 162397.17 with a p-value of 0.0000 indicates that the overall model is significant (p-value less than 0.05).

The log likelihood value of -67636.483 measures the goodness-of-fit of the model and the Pseudo R2 of 0.5456 gives an indication of the proportion of the total variation in the outcome variable that is explained by the predictor variables.

The coefficients table shows the estimated coefficients, their standard errors, z-scores, p-values, and confidence intervals for each predictor variable and the constant term. The coefficient of .5549409 for the predictor variable "_hat" represents the change in the log odds of the outcome for a one unit increase in "_hat" (holding all other variables constant), and the corresponding p-value of 0.000 indicates that this predictor is significant in predicting the outcome.

Overall, the model specification appears to be correct, and the results show that the model has good predictive power and is significant in explaining the outcome variable.

Measures of Fit for logit of exit, Akaike's Information Criterion (AIC)/Bayesian Information Criterion (BIC)

In the present study, measures of fit for the logit of exit were evaluated using the Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). These measures are commonly used to assess the quality of statistical models and to compare alternative models.

The BIC statistic was used to determine whether the current model was preferable over the null model. A negative BIC' value was considered to indicate that the model fit the data sufficiently well to justify the number of parameters used. The more negative the BIC' value, the better the model fit was considered to be.

The BIC test was conducted to evaluate the ability of the model to explain the observed data. This allowed for a determination of whether the current model was a suitable representation of the underlying relationship between the variables of interest.

Log-Lik Intercept Only:	-148835.067	Log-Lik Full Model:	-147401.345
D(295288):	29.4802691	LR(3):	2867.443
		Prob > LR:	0.000
McFadden's R2:	0.010	McFadden's Adj R2:	0.010
Maximum Likelihood R2:	0.010	Cragg & Uhler's R2:	0.015
McKelvey and Zavoina's R2:	0.922	Efron's R2:	0.009
Variance of y*:	42.388	Variance of error:	3.290
Count R2:	0.797	Adj Count R2:	0.000
AIC:	0.998	AIC*n:	29.4810691
BIC:	-3.425e+06	BIC':	-2829.656

The model is a logistic regression model. The Log-Lik values indicate the log-likelihood of the data given the model, and the smaller the log-likelihood value, the better the fit of the model to the data. The D(29.5288) value is the Deviance, which measures the lack of fit of the model to the data, and a smaller value indicates a better fit. The D(295288) and LR(3) values are tests for the overall significance of the model, with a probability value of 0.000, indicating that the model is highly significant.

The full model has a slightly better fit than the intercept-only model, as the log-likelihood is lower.

The LR (Likelihood Ratio) test compares the fit of the full model to the fit of an intercept-only model, and the Prob > LR value is the p-value associated with the LR test. A p-value less than 0.05 indicates that the full model is significantly better than the intercept-only model.

The AIC and AIC*n are measures of the relative quality of a statistical model, and smaller values indicate better models. The BIC and BIC' are similar measures that take into account the number of parameters in the model.

The AIC and BIC values provide measures of the relative quality of the model, with lower values indicating a better fit. The values of AIC and BIC in this model indicate that the model is a good fit.

APPENDIX B: SEARCH PROTOCOL

A systematic literature review was conducted to explore the phenomenon of firm turnover behavior. The search was limited to peer-reviewed electronic journals and spanned the period from 1996 to present. The initial search was conducted using several online databases including Jstor, Wiley Online, and Econlit, which are maintained by the University of Toronto Library. A total of 1,254 articles were retrieved, which were narrowed down to 58 articles that met the criteria of being peer-reviewed, published in English, and having publication years ranging from 2014 to 2017. No other limitations were imposed in the selection process.

The titles of the articles were first screened for relevancy, and then the abstracts of the potentially relevant articles were examined using established inclusion criteria. To be eligible for inclusion, a study must have utilized a measure of firm characteristics such as age and employment size, used tests for statistical significance or included confidence intervals, been published in a peer-reviewed journal, and been published in the English language.

Key search terms were established based on the research question and publication years, and were searched in various online resources and journal databases, including Jstor, Wiley Online, Econlit, www.oecd.org, www.imf.org, and Google Scholar. The search results were further narrowed down by including the term "Canada" in some of the searches.

In addition to the general search terms, specific searches were also conducted using terms related to firm survival, turnover, mobility, entry and exit, probability, minimum wage, probit, and logit/ logistic regression. The results of the searches in each database are provided in the text. The most recent articles were captured by using the search terms "Firm" AND "entry and exit" AND "Canada" AND "2017."

The online resources and journal databases used in this literature review are listed as follows: Jstor, Wiley Online, Econlit (which can be accessed through the Ministry of Finance's internal intranet page), www.oecd.org, www.imf.org, and Google Scholar. The methodology and data used to prepare the Manufacturing Firms Relocation (MFR) dataset are described below, along with the limitations of the data.

APPENDIX C: DATA METHODOLOGY

In preparation for the Manufacturing Firms Relocation (MFR) dataset, the following methodology and data sources were utilized with consideration for the limitations present.

The data used in the analysis was obtained from return, account, and corporation levels. The corporate tax data was stored at the return level, with each corporation having the potential to file multiple returns for a single taxation period. In such cases, the information from the latest return was selected. Additionally, each corporation could have multiple accounts, with a separate return filed for each account, each of which is identified by a full 15-digit Business Number. To create the dataset at the corporation level, the account level data was aggregated based on the first 9 digits of the Business Number.

The MFR dataset uses calendar years, while personal income tax and payroll data are reported on a calendar year basis. However, a corporation's taxation year is not necessarily aligned with the calendar year. To convert the corporate tax data to a calendar year basis, the corporation was aligned to the calendar year based on its taxation year-end. For example, corporations with a taxation year ending between January 2009 and December 2009 were assigned to the calendar year 2009. During the conversion process, it may be necessary to aggregate amounts for some corporations that filed multiple returns or underwent mergers over the same period.

The MFR dataset contains data from a company's balance sheet (Schedule 100). The balance sheet is a financial statement that summarizes a company's assets, liabilities, and shareholders' equity at a specific point in time. For all fields derived from Schedule 100, the data from the latest return in the calendar year was selected.

The calendar year in the MFR dataset is derived from the corporation's taxation period end date. An anonymous company identifier was created by assigning each nine-digit business number a unique random number, ensuring that the same company is assigned the same identifier in all years. The Ontario Allocation Factor (OAF) was calculated based on information from Schedule 5 of the T2 corporation income tax return. The type of corporation was reported on the T2 corporate income tax return, box 040. The Forward Sortation Area (FSA) of the head office was determined by the first 3 digits of the corporation's head office postal code, reported on the T2 corporate income tax return.

The age of a corporation was estimated by subtracting its year of incorporation from its taxation year-end in the calendar year. However, the year of incorporation may change due to changes in the corporate structure, so the earliest year of incorporation available in the database was selected for each corporation. Additionally, the age of the business may be greater than the age of the corporation if the corporation was a continuation of an unincorporated business or a previous corporation. The corporation's North American Industry Classification System (NAICS) code was reported on its corporate income tax returns, with the most recent code used in cases where multiple records were aggregated into a single record.

The MFR dataset also includes the amount of Manufacturing and Processing Credit claimed on the income tax return, as well as data on land, depletable assets, buildings, machinery, equipment, furniture, and fixtures, and other tangible capital assets. The value of these assets was reported on Schedule 100 and includes assets located outside Ontario. The value of accumulated amortization for each asset was also reported. The total value of tangible capital assets (before amortization) was reported on item 2008 of Schedule 100.

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Inflation and Economic Growth: An analysis of the inflation threshold level of the Nigerian economy

Abdulmalik Sadiq

Abstract

The relationship between Economic growth and Inflation has been for long a very interesting topic for many decades in the macroeconomic domain and for many researchers. While the linkage between the two variables has been debatable for many years, the determination of a stable, high and sustainable economic growth tends to be achieved in most cases with low or moderate inflation. As high inflation possess a lot of risk to an economy, low or moderate inflation on the other hand is considered beneficial for efficiency in the economy.

This paper aims to determine an optimal level of inflation for the Nigerian economy using the annual data set from 1960 to 2018. In addition, the paper will find out the existence if any, of the relationship between Economic growth and Inflation. Furthermore, not only the relationship between the two will be of interest, also the co-integrated relationship using the Error Correction Model (ECM) will be of interest, as well the threshold level of inflation.

The results indicate that there exist a positive long-run relationship between Economic growth and Inflation in Nigeria. However, with the non-linear relationship between the two variables, it was observed that the Nigerian economic growth is at its peak at a 6% inflation point/level.

Keywords: Economic growth, Inflation, Inflation threshold, Augmented Dickey-Fuller, PP, Error Correction Model

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Introduction

Inflation and Economic growth

Monetarist theory which is based on the contribution made by Milton Friedman, He emphasized that change in money supply is the most important determinant of economic growth because of the effect it pose on the rate of inflation. The monetary theory was found by **Friedman & Schwartz (1970),** in their model they express the monetary policy of the central bank to be channeled towards stabilizing economic growth and the behavior of the business cycle is ultimately linked to money supply. However, in his assertion (Blinov, 2017) concluded that economic growth is not only by transmission mechanism growth rates of both money supply and prices could be an indicator as well (Volodymyr et. al, 2018).

Economic theory of money

Quantity of money theory is based on two approaches:

Cash balance approach (Cambridge version)

$$\pi = \delta R / M \qquad \ldots\ldots 1.$$

π– purchasing power of money

δ-proportion of income that people hold in the form of money

R-volume of real income

M-stock of supply of money in a country

π varies directly as δ or R and inversely with M.

π is the reciprocal of the general price level, which is $\pi = \frac{1}{p}$

$$\frac{1}{p} = \delta \frac{R}{M} \qquad \ldots\ldots 2.$$

Or

$$p = \frac{M}{\delta R} \qquad \ldots\ldots 3$$

And

$$\frac{dP}{dM} = \frac{1}{\delta R}$$
………………………………………………………………………….
…….4

The above equation shows that growth increase or changes with money supply.

Transaction approach (Fisher's version) to the quantity theory of money

$$MV = PT$$
……………………………………………………………………
…………….5

M is the total supply of money

V is the velocity of circulation

P is the general price level

T is the total transactions in physical goods

The equation further depicts the negative relationship between production, employment and price levels as to the change in the money supply.

Neoclassical growth theory

This theory explains the stability of economic growth rate to be achieved with three factors:

Capital, Labor and Technology.

According to the theorists Solow (1956) and Swan (1956)

$$Yt = f(kt, lt)$$
……………………………………………………………………
……….. 6

Yt is the output, kt is the capital and lt is the labor at time t=0, 1, 2…,

Law of motion for the capital stock is introduced $k_{t+1} = (1-\sigma)kt + \mu yt$

Where $\sigma\epsilon(0,1)$ is the depreciation rate and $\mu\epsilon(0,1)$ is the saving rate.

We substitute (6) into law of motion for capital:

$$Kt + 1 = (1-\sigma)Kt + \mu f\left(kt\right) = g(kt)$$
……………………………………………..…….7

Given this path, a path of output (yt) can be derived. A steady state of the system is a solution to K =g (k).

The growth accounting model as provided Abramovits (1956) and Solow (1957):

$$\left[Y*\frac{t}{Y(t)}\right]-\left[L*\frac{t}{L(t)}\right]=\alpha k(t)[\left(K*\frac{t}{K(t)}\right]-\left[L*\frac{t}{L}(t)\right]+R(t)........................ $$
8

$$Y*\frac{t}{Y(t)} Growthrateofoutput$$

$$L*\frac{t}{L(t)} GrowthrateofLabor$$

$$K*\frac{t}{K(t)} GrowthrateofCapital$$

$\alpha k(t)-$ Elasticity of output with respect to capital at time t, and R(t) is the Solow residual which explains the total factor of productivity.

J. de Gregorio (1996) explains how inflation affects long run growth based on neoclassical approach:

$$Yt=\theta f(Kt,Lt)..9$$

Where, Yt is the output at period t, θ is a technological parameter, and Kt and Lt, are the stock of capital and employment in period t, respectively.

Differentiating we obtain

$$Y=\theta f'(Kt,Lt)i..10$$

Where, y is the rate of growth of output $\left(Y=\frac{dlog(yt)}{dt}\right)$, $\theta f'(Kt,Lt)$ is the marginal productivity of capital, I is the investment rate, $\left(\frac{1}{Y}\right)\left(\frac{dK}{dt}\right)$.

Growth could be generated by an increase in the rate of investment or an increase in the marginal productivity of capital $\theta f'(kt,lt)$.

If we assume that f is a linear in k, such that f is an increasing function of *lt*, decline in $f'(kt,lt)$ leads to a decline in the rate of growth, since capital accumulation becomes less efficient.

When individuals chooses between consumption and leisure, and to buy consumption goods individuals face a cash-in-advance constraint. Since individuals will have to hold money in order to purchase consumption goods, the effective price of consumption goods will include the rate of inflation. Thus, an increase in inflation rate will raise the price of consumption with respect to the price of leisure inducing substitution from consumption to leisure, and thereby reducing the labor supply. Hence, an increase in inflation will reduce the efficiency of investment and the rate of growth.

Effect of Inflation on the Nigerian economy

The absence of inflation in an economy may result to a deflation (decrease in prices), which may lead to less productivity and wage cuts as shown in many literatures and supported by **(Khan & Senhadji, 2001**) when they show the complexity of inflation in their work.

Researches have proven that developing countries are very lax when it comes to monitoring and controlling monetary and fiscal policies which usually hinders their economic growth **(Volodymyr et al, 2018),** which deems it necessary for every country to implement Anti-inflation policy especially developing countries **(Mischenko, Naumenkova, & Lon, 2016).**

Volodymyr et al, 2018, claimed that inflation does not necessitates a negative growth as economic growth can be ascertain even under high inflation or deflation because high inflation rates is neither a measure of strength nor it portrays the weakness of an economy. This view is in support of **(Khan & Senhadji, 2001)** that inflation can easily be achieved using instrumental approach.

The work of **Sweidan (2004)** shows a 2% inflation as detrimental to the growth of any economy (without distinction between developed and developing economies) this analogy could be an indication of the why the Nigerian economy that hasn't recorded an inflation of less than 5% for more than two decades is still underperforming.

Oladipo and Akinbobola (2011), opined that the Nigerian government influences the economy using fiscal instrument, mainly budget deficit, although it has been known that this instrument does not help in maintaining stability in the economy because it affects some of the macroeconomics variables as in the view of **Volodymyr et al, (2018)** that the macroeconomic policies embark by the policy makers may be helpful in stabilizing the economy through growth increase, unemployment reduction and a decrease in inflation. This is in connection with the view of **Oladipo et al, (2011)** which further stated that the impact of budget deficit was suffered by the Nigerian government in the late 90s.

The effect of inflation on the Nigerian economy was noticed by **Aminu and Anono (2012), Ogwu (2010)** and **Nembee and Madume (2011).** In the view of Aminu and Anono (2012), increase in inflation is negatively correlated to the unemployment in the short haul; while in the long term the duo follow the Philips curve. However, Ogwu (2010) postulated that the cost push inflation might be a product of the depreciation of the Nigerian Naira as a result of the rise in the prices of imported goods. This rise in price of the imported goods will further escalate to the demand in the wage increase by the worker.

According to **Ekpo (1995),** he emphasized on the fact that the level of inflation needs to be maintained below the threshold in Nigeria by the policy makers in other to encourage FDI, in addition to the stability in political regime, debt service, real income per capital, world interest rate and credit rating. The high level of inflation in Nigeria could be underscored by some factors as in the study of **Fatukasi (2012)** such as; Government deficit financing, import and export in addition to money supply which are responsible for inflation in Nigeria.

Review of related literature

The relationship between inflation and economic growth has been in existence for many decade since the inception of the monetarism of the central bank for stabilizing the inflation, regulating money circulation as well as controlling the unemployment rate **(Volodymyr et. all 2018).**

Mundell (1963) and Tobin (1965) showed the connection between inflation and economic growth in their study. According to their model, an increase in nominal interest rate is triggered by inflation (price increase) resulting to investment than consumption. An increase in investment is usually accompanied by the accumulation capital, which will in turn increase (yield) economic growth. Their theory is known as the (Mundell-Tobin effect).

Sidrauski (1967) investigated the relationship between inflation and economic growth in his renowned model, where he indicated that money has no effect on the stability of the economy "Steady state"

Stockman (1981) proposed a growth model with "cash-in-advance constraint" that investment and real money balances are compliments which contradicts **Mundell (1963)** and **Tobin (1965)** which stated that investment and real money are substitutes. This model showed that investment and real money balances decrease the rate of inflation base on the return on investment received by the investor (individual) in the future. However, he opined that inflation affect economic growth negatively.

De Gregario (1992) realized in his survey of 12 Latin American countries using the data pool of 1950-1985 with the use of the GLS (Generalised Least Squares) and concludes on the negative relationship of inflation and economic growth.

In his analogy, **Fischer (1993)** with the role of macroeconomic factors, he found the negative relationship between inflation and growth through reducing growth in productivity and investment. Also, he emphasized the impact of high inflation (hyperinflation) on the economic growth.

Barro (1995) concluded that inflation is negatively related to economic growth base on his study for the period of 1960-1990 where he employed panel data of about 100 countries. He further stated that a 10% increase in the average inflation annually could inhibit GDP growth rate by 0.2-0.3%.

Sarel (1996) based on his study using a 20 year panel data of 87 countries; he claims that the non-linearity impact of inflation and economic growth could be viable or plausible. According to his outcome, at 8% the economy stands a possibility of growth, however, in his own view, inflation does not impact the economy at any percent below 8 point, but inflation exceeding 8 point could inhibit economic growth rate.

Paul Kearney & Chowdhury (1997) in their research related the inflation growth analysis using a 70 countries surveys between the periods 1960-1989. They came up with a causality model between inflation and economic growth.

Countries	Relationship	Percentage
28	*No causal relationship*	40%
14	*Bi-directional relationship*	20%
28	*Uni-directional relationship*	40%

Bruno & Easterly (1998) in their study of 26 countries affected by inflation crises within the period 1961-1992, they concluded that for perfect inflationary measures during the time of crises, the inflation threshold should not exceed 40% at max. In addition, they found out that, low and moderate inflation could or may not be harmful to the economy.

The existence of inflation threshold was among the breakthrough in the macroeconomic research. Within this paradigm, **Khan and Senhadji (2001)** in their study for a period of about 38 years which panel data of 140 countries. Their contributions were very excellent with findings that 1-3% and 11-12% inflation thresholds for developed and developing countries respectively.

Furthermore, **Mallik and Chowdhury (2001)** came up with model to determine the short and long term effect of inflation and economic growth using the Error Correction Model (ECM) model. They found that in the long run inflation and economic growth are positively related and significant statistically to each other. However, their research result was not in conformity with the relationship that existed between the two variables in the short run. Contrary to the findings of Fischer (1993) and Barro (1995), they found out that inflation and economic growth has negative relation. In addition, they asserted that the sensitivity of inflation to changes in growth rates to be higher than that of growth to changes in inflation rates.

Mubarik (2005) embark on finding the threshold level employing the Granger Causality test in Pakistani economy where he considers the annual data of 1973-2000. His conclusion suggested that crossing the 9% inflation rate is harmful for the Pakistani economy.

Ahmed and Mortaza (2005) investigate the empirical relationship between inflation and economic growth for the period 1981 to 2005 for Bangladesh economy using the co-integration and ECM. They found an important policy issue for the economy the threshold level of inflation for the stability of the economy. The findings exerts that there is a statistically significant long-run negative relationship between inflation and economic growth.

The short run relationship between inflation and economic growth was confirmed by **Erbaykal and Okuyan (2008) in** their research when they examined the relationship between inflation and economic growth in Turkey. The researchers employed the bind test methodology developed by **Peseran et al (2001)** where they found a short-run relationship between inflation and economic growth.

Munir et al. (2009) explored a nonlinear relationship between inflation and economic growth using data of 1970-2005 in Malaysia where they predict 3.89% as the efficient threshold level beyond which the inflation impacts growth negatively.

Iqbal and Nawaz (2009) conducted a study on the relationship between inflation, investment and economic growth, where they tried to find the existence of a second inflation threshold point for the Pakistan economy using annual time series data from 1961 to 2008. The result revealed the existence of two threshold points at 6% and 11% level. It was also clearly from the result that below 6% (the first threshold) a positive relationship was realized between inflation and growth; when inflation is in between the two thresholds (6-11%), it becomes negative. However, if inflation exceeds the second threshold, it affects growth negatively but the effect diminishes. In conclusion, they suggested maintaining the inflation below the first threshold level will promote investment and sustainable growth minimizing uncertainty.

Frimpong and Oteng-Abayie (2010) examined the threshold level of inflation for Ghana using time-series annual data for the period 1960-2008. They employed the inflation threshold regression and found that $\mathbf{R^2}$ is maximized at 11% which is also examined by the two stages least square estimation. the authors concluded by recommending to the Bank of Ghana and the policy makers to rethink its target of inflation as the targeted 7% inflation is less than the threshold level inflation from their research.

In his research, **Hasanov (2011)** examined the inflation and growth nexus through estimating the threshold point for Azerbaijan using annual data period 2001-2009. His analysis using Least square and two stages least square estimation models shows close estimation results indicating 13% of inflation as a threshold level. The author concludes that in Azerbaijan, a positive relationship between inflation and growth exists when the inflation rate is below 13% and above this level of inflation the relationship tends to be negative.

Pahlavani and Ezzati (2011) studied the relationship between inflation and economic growth of Iran for the period 1957-2007 to check the structural break point effect and found the threshold level of inflation lies between 9% and 12%.

Lupu (2012) tried to evaluate the interrelationship between inflation and economic growth in Romania for the period 1990 to 2009 considering the period after the fall of the communist. The researcher based the study period into two decades where in the first decade, (1990-2000), high and volatile inflation was the major cause of macro-economic instability which reduces the GDP. In conclusion, the result of the research showed a negative relationship between inflation and economic growth in Romania.

Using co-integration and ECM, **Raza and Naqvi (2013)** in their study of the short-run and long-run relationship between inflation and economic growth of Pakistan found statistically significant long-run positive relationship between the two macroeconomic variables.

Kasidi and Mwakanemela (2013) investigate the controversial relationship between economic growth and inflation of Tanzania for period 1990 to 2011 using correlation coefficient and co-integration technique. The variable of coefficient of elasticity revealed a negative impact of inflation on economic growth and interestingly found no co-integration and long run relationship between inflation and economic growth of Tanzania.

Hussain and Saaed (2014) studied the relationship between inflation and economic growth of a Gulf member country; Qatar from 1980 to 2011. They applied the co-integration and ECM models, the result indicated a significant negative relationship in long-run between the two variables.

In their recent study, **Ahmed and Zaid (2016)** examine the threshold level of inflation in the US during the period 1960 to 2011. They applied the same model as developed by Khan and Senhadji (2001), the model suggests the quarterly threshold level of inflation in the US is between 0% and 1.5%. Above that threshold level, inflation has significant negative effect on the real GDP growth, while below that threshold level, the effect of inflation on the real GDP growth is ambiguous (uncertain).

Umi and Izuchukwu (2016) conducted study on the relationship between inflation and economic growth from 1985 to 2013 for Nigeria using Engle-Granger two step co-integration method and ECM. By both methods they found long run relationship between inflation and economic growth. Finally found that moderate inflation in the economic system can accelerate the economic growth.

Sumon and Miyan (2017) employed co-integration and ECM to examine the long and short run dynamics of economic growth and inflation of the Bangladesh economy for the period 1986-2016. The papers concludes with a statistically significant long run positive relationship between the two macroeconomic variables as well as 8% inflation threshold.

Methodology and Model specification

To achieve the main objective of the study in other to reach the goal of determining the relationship between growth and inflation we employ the following steps;

1. **Testing the stationarity** of a series requires determining the unit root in levels and first differences. To further the test, the Augmented Dickey-Fuller (ADF) test by [Dickey & Fuller (1981)] and Phillips-Peron [PP] test by [Phillips and Perron (1988)] will be applied on the following equations:

$$\Delta Xt = \beta 1 + \pi 1 Xt - 1 + \sum_{i=1}^{n} P1 \, \Delta Xt - 1 + e \ldots\ldots 11$$

$$\Delta Xt = \alpha + \pi 2 X - 1 + \varnothing\left(t - \frac{T}{2}\right) + \sum_{i=1}^{m} \varphi i \, \Delta Xt - 1 + e \ldots\ldots 12$$

Where e_{1t} and e_{2t} are covariance stationary random error terms of zero mean. Δ is the first difference operator and X_t is a variable that denoted (GDP and INFL). The lag length n (for ADF test) is determined by Akaike's Information Criteria (AIC) by (Akaike (1973)), and m (for PP test) which is obtained based on the work by Newey-West's (Newey & West) (1987)).

To test the null hypothesis of non-stationarity, a standard t-test on critical values will be employed as in Mackinnon (1991). However, rejecting the null hypothesis will be dependent by the values of π_1 and π_2 less than 0 and statistically significant and hence, X_t will be termed a non-stationary time series.

Replacing Xt with the Growth and Inflation variables in equation 11 (ADF test) and 12 (PP test) will give:

$$logGDPt = \alpha 0 + \alpha 1 logINFLt + u \ldots\ldots 13i$$

$$logINFLt = \alpha 0 + \alpha 1 logGDPt + \mu t \ldots\ldots 13ii$$

Where,

$logGDPt$ denotes the log of real Gross Domestic Product and

$logINFLt$ denotes the log of Inflation index.

ut and μt are random error terms with zero means (μ).

The ADF and PP unit root tests are applied on ut and μt using equations (11) and (12) in ut and μt terms respectively instead of Xt.

The terms ut and μt are the errors that specify or show the extent at which $logGDPt$ and $logINFLt$ are disequilibrium. The co-integration and lack or no-co-integration shows the long-run relationship or the non-existence of long-run relationship between Economic Growth and Inflation rate.

From the above equations (13(i)(ii)), the existence of integration of order zero I(0) between ut and μt will bring about the conclusion that ($logGDPtandlogINFLt$) are co-integrated and share a stable relationship in the long-run.

2. The **second step** is the application of the Johansen test named after the Danish statistician Soren Johansen (Johansen (1988)), is a phenomenon for testing co-integration of more than one time series. Johansen, Soren (1991)

The Johansen tests will show the likelihood ratio [LR] statistics for the number of co-integrating vectors in this case ($logGDPt$ and $logINFLt$) as in the equations 13 (i)(ii). The null hypothesis is denoted by r in the case of Johansen test. If r=0 (which show a no co-integration) the null hypothesis will be rejected hence, it can be concluded that ($logGDPt$ and $logINFLt$) are co-integrated (no co-integration).

3. Error Correction Model

This estimation technique is used to estimate both short and long term effects of one time series on another. In the case of this study it will be employed to estimate or determine the short and long term effect of GDP on INFL or vice versa. The Error Correction Model of the first difference for the GDP and INFL will have the form:

$$\Delta logGDPt = \varnothing 10 + \sum_{J=0}^{S} \varnothing 11j \, \Delta logINFLt - j + \sum_{i=1}^{q} \varnothing 12i \, \Delta GDPt - 1 + t1ut - 1 + e3t \ldots\ldots 14i$$

$$\Delta logINFLt = \varnothing 20 + \sum_{J=0}^{S} \varnothing 21j \, \Delta logGDPt - j + \sum_{i=1}^{q} \varnothing 22i \, \Delta INFLt - 1 + t2\mu t - 1 + e4t \ldots\ldots 14ii$$

Δ denotes the first difference operator, $ut - 1$ and $\mu t - 1$ are the error correction terms from (13i) and (13ii) respectively, whereas $e3t$ and $e4t$ are random disturbance terms, t1 and t2 show the deviation of the dependent variable from the long-run equilibrium. Akaike Information Criterion (AIC) will be used to determine the number of lag lengths.

Based on the available literature, the ECM Model was used by Sargan (1984) and later Engle and Granger (1987) who proposed the theorem of Granger Representation Theorem as stated: if two variables are co-integrated, the link between the two can be defined as ECM.

As the objective of the ECM is based on determining the short-run adjustments of the co-integrated variables as well to keep the i begins at one and j begins at zero as proposed by [Engle and Yoo (1991)]. However, convergence of the series to the long-run equilibrium mandates $0 \leq t1,t2 \leq 1$ positive relationship.

4. Inflation threshold level

The threshold level of inflation using the model by Khan and Senhadji (2001), the equation takes the form:

$$\Delta logGDPt = \beta 0 + \beta 1(\Delta logINFLt) + \beta 2{*}Dt(\Delta logINFLt - k) + \beta 3(\Delta logGCapt) + \beta 4(\Delta logTTDt) + \beta 5(\Delta logPOPt) + Et$$

…………………………………………………… 15

Δdenotes first difference operator,

LogGDPt log of real Gross Domestic Product

LogINFLt log of consumer price index

K is the threshold level of inflation

LogGCapt log of gross capital formation

LogTTDt log of total trade

LogPOPt log of population

Et error term

*logGCapt, logTTDt and logPOPt are control variables and D is a dummy variable from the construct:

Dt=1 if $\Delta logINFLt > k$; Dt=0 if $\Delta logINFLt \leq k$.

Assumption

The parameter k, which is a threshold level of inflation, has a property that the relationship between inflation and economic growth is given $\beta 1$as in equation (15) when there is a low rate of inflation; and $\beta 1 + \beta 2$ when there is a high rate of inflation.

Estimating the regressions for different values of k, choosing in increasing order (i.e. 3,…, 7,), the value that maximizes the R^2 is defined as the optimal value of k.

Data source

The Data for the Gross Domestic Product (GDP) and the Inflation (INFL) were obtained from the World Bank database. In other to have a precise data for the values; the Economic growth rates was determine using the difference of logs GDP ($\Delta\, logGDP$) and the inflation rates using the difference of logs INFL ($\Delta\, logINFL$)

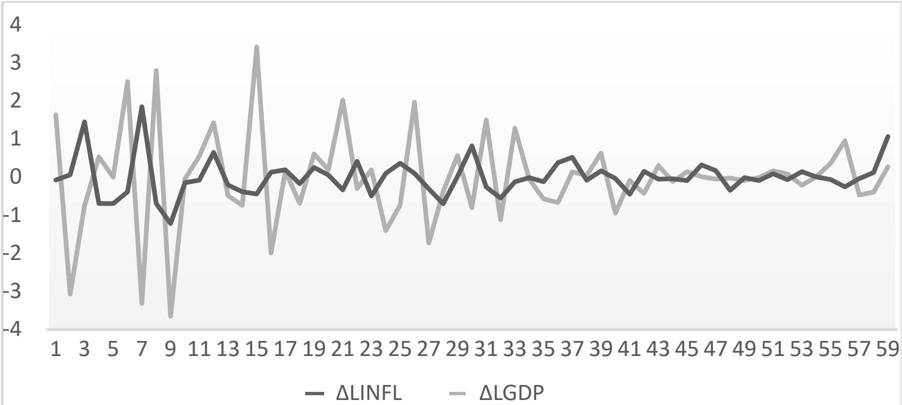
The Descriptive statistics of the GDP and INFL is showed below:

Variable	Observations	Mean	Std. Dev.	Max	Min
Growth	59	0.0000	1.2813	3.4361	-3.6411
Inflation	59	0.0125	0.4944	1.8661	-1.2063
Money	59	1.1578	0.1443	1.4567	0.9573

Table 1: Descriptive statistics

From the figure above, Growth and Inflation seems to share a common trend, this is because the spread of the mean and standard deviation is not very high.

Figure: Economic growth rate and Inflation rate over the period of 1960 to 2018 in Nigeria



Test for stationarity

For the test of the unit root, we employ the test in levels (logGDP and logINFL) and in the first differences ($\Delta logGDP and \Delta logINFL$)for the Economic growth and Inflation respectively

Table 2: ADF and PP unit root tests in levels and first differences

Variable	A D (Intercept)	ADF (Inte and trend)	PP (Intercep	PP (Intercep trend)	K P S (Intercept	K P S (Intercept trend)
logGDP	-1.099523(	-1.602997(0	-1.119658(3	-1.823691(3	1.318781	0.143158(3
logINFL	-4.014721(	-4.473874(1)	-3.775028(3)	-4.126876(3)	0.526105(	0.239026(3
logMone	-2.155846(	-2.595429(0)	-2.277094(1)	-2.754516(1)	0.457529(	0.123315(5
$\Delta logGDP$	-6.357625(	-6.328946(0)	-6.338376(3)	-6.307223(3)	0.098259(	0.079940(3
$\Delta logINFL$	-5.836660(	-5.983537(5)	-9.745568(3)	-9.632340(3)	0.058746(	0.051747(3
$\Delta logMoney$	-6.976827(	-6.913535(0)	-7.152315(6)	-7.067044(6)	0.063027(	0.061705(5

Notes:

LogGDP and logINFL both denotes the log of GDP and INFL respectively; Δ denotes first difference.

ADF and PP tests are based on null hypothesis of unit root.

Critical values as in Mackinnon (1991) for rejection of the null hypothesis are applied.

***,**,and * are the significance at 1%, 5% and 10% level respectively.

Values within parentheses indicate the lag length.

From the table above, it could be depicted that all the test results in levels for logINFL are not in support of the null hypothesis (stationarity). However, the test result for the LogGDP accepted the alternative hypothesis (non-stationarity).

The obtained results shows all the variables are stationary in difference, while the results in levels clearly showed that the test for logGDP is as well non-stationary which contradicts the test for logINFL for both the ADF and PP using the intercept and intercept & trend. The KPSS result as well shows a similar results as compared to the ADF and PP tests. The difference as clearly showed that (LGDP) is non-stationary in levels, while the (LINFL) is stationary and integrated of order zero *I(0)*, while all the variables for the ADF and PP tests are stationary at the first difference and integrated of order one, *I(1)*.

In conclusion, it can be summarized that both GDP and INFL are stationary and integrated of order one, *I(1)* as shown in the summary table, this is because all the tests at differences rejected the null hypothesis of unit root for the two variables (GDP and INFL).

Table 3: ADF, PP and KPSS unit root tests in levels and first differences summary

Variable	ADF (Inte	ADF (Inter trend)	PP (Interc	PP (Intercept	KPSS (Int	KPSS (In and trend)
logGDP	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
logINFL	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)
LogMon	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
$\Delta logGDP$	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
$\Delta logINFL$	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
$\Delta logMoney$	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)

Co-Integration relationship between Economic growth and Inflation

Table 4: Coefficient of the independent variables and the unit root tests for the residual

The coefficient of the independent variables and the unit root tests for the residual will be determine from equations 13 (i and ii) for the values of ut and μt. The ADF and PP will both be applied for the tests.

Coefficient of logINFL	Unit Root Tests for the Residual, ut	
	Augmented Dickey-Fulle	**Phillip-Perron**
0.416970	2.845474(1)*	2.600608(3)*
Coefficient of logGDP	Unit Root Tests for the Residual, μt	
	Augmented Dickey-Fulle	**Phillip-Perron**
0.908324	1.687082(0)***	-1.602997(3)
Coefficient of logMoney	**Augmented Dickey-Fulle**	**Phillip-Perron**
0.187983	2.222910(0)**	-2.155846(1)**

Notes:

LGDP and logINFL both denotes the log of GDP and INFL respectively; Δ denotes first difference.

ADF and PP tests are based on null hypothesis of unit root.

Critical values as in Mackinnon (1991) for rejection of the null hypothesis are applied.

***,**,and * are the significance at 1%, 5% and 10% level respectively.

Values within parentheses indicate the lag length.

The table above shows the results of the Augmented Dickey-Fuller and Phillip-Perron tests for the residuals as presented. The result is aimed at giving the picture of the co-integration between the two variables (GDP and INFL).

As shown from the results, it could be seen that the residuals are integrated order of zero I(0). From the above result it could be concluded that both the Economic growth and Inflation are co-integrated and therefore a valid and positive long-run relationship exist between the two variables.

Johansen test for co-integration

Table 5: Johansen test result

The Johansen test as shown in table 5, reveal the same result as the likelihood ratio [LR] statistic indicates a co-integrating equation at 5% significance level. The result of the table can be translated as follows:

i. The null hypothesis will be rejected (No co-integration between Economic growth and Inflation)

ii. There is a long-run relationship between Economic growth and Inflation

Maximum Eigenvalue Test				
Hypothesized No. of CE(s)	Eigenvalue	Likelihood Ratio	5% Critical Valu	Prob.
None*	0.285389	19.15300	21.13162	0.0925
At most 1	0.162681	10.12033	14.26460	0.2042
At most 2	0.021707	1.250897	3.841466	0.2634

Trace Test				
Hypothesized No. of CE(s)	Eigenvalue	Likelihood Ratio	5% Critical Valu	Prob.
None*	0.285389	30.52423	29.79707	0.0412
At most 1	0.165681	11.37123	15.49471	0.1897
At most 2	0.021707	1.250897	3.841466	0.2634

Note: ** denotes rejection of the null hypothesis at 5% significant level.

The above result could be translated in terms of the work of Omoke and Oruta (2010) to determine the relationship between inflation and economic in Nigeria using Johansen-Juselius Co-integration techniques in a multivariate context. They came up with the conclusion of no co-integrating relationship between the two variables.

Error Correction Model

Based on the Granger representation theorem, when two variables are co-integrated, the Error Correction Model (ECM) is necessary to describe the short-run dynamics of the co-integrated variables towards the equilibrium values.

The ECMs are based on the equations (14i and 14ii).

$$\Delta logGDPt = \varnothing 10 + \sum_{J=0}^{S} \varnothing 11j\, \Delta logINFLt - j + \sum_{i=1}^{q} \varnothing 12i\, \Delta GDPt - 1 + t1ut - 1 + e3t \ldots\ldots 14i$$

$$\Delta logINFLt = \varnothing 20 + \sum_{J=0}^{S} \varnothing 21j\, \Delta logGDPt - j + \sum_{i=1}^{q} \varnothing 22i\, \Delta INFLt - 1 + t2\mu t - 1 + e4t \ldots\ldots 14ii$$

Table 6: Error Correction Model

Error Correction	$\Delta logGDP$	$\Delta logINFL$	$\Delta logMoney$
Constant	0.427112 (0.25191) [1.69552]	-1.326360 (1.07487) [-1.23397]	-0.193771 (0.19529) [-0.99224]
$\Delta logGDP$(-1)	1.169072 (0.14454) [8.08802]	0.319418 (0.61676) [0.51790]	0.085509 (0.11205) [0.76310]
$\Delta logGDP$(-2)	-0.237865 (0.14033) [-1.69501]	-0.155277 (0.59879) [-0.25932]	-0.029479 (0.10879) [-0.27097]
$\Delta logINFL$(-1)	0.017656 (0.03239) [0.54501]	0.618757 (0.13823) [4.47637]	-0.034702 (0.02511) [-1.38179]
$\Delta logINFL$(-2)	0.002968 (0.03265) [0.09091]	-0.182297 (0.13932) [-1.30847]	0.006451 (0.02531) [0.25484]

$\Delta logMoney$(-1)	0.471949 (0.18930) [2.49308]	1.182744 (0.80775) [1.46425]	0.902037 (0.14675) [6.14658]
$\Delta logMoney$(-2)	-0.199914 (0.19900) [-1.00459]	-1.073947 (0.84913) [-1.26477]	-0.225462 (0.15427) [-1.46146]
R-squared	0.976207	0.397473	0.740529
Adj. R-squared	0.973352	0.325169	0.709392
Sum sq. resids	0.489183	8.906505	0.293992
S.E. equation	0.098912	0.422055	0.076680
F-statistics	341.9059	5.497295	23.78327
Log likelihood	54.72547	-27.97582	69.23726
Akaike AIC	-1.674578	1.227222	-2.183763
Schwarz SC	-1.423677	1.478123	-1.932862
Mean dependent	10.76403	1.016430	1.16477
S.D. dependent	0.605919	0.513773	0.142242

Notes:

Standard errors within parentheses

***,**and * significance at 1%, 5% and 10% levels respectively comparing critical t statistics from the standard t-table.

The result as presented in Table 5 shows a long-run equilibrium relationship between Economic growth and Inflation i.e. (the series cannot move independently of each other or cannot move too far away from each other). The co-integration between the two variables suggests that in the short-run, there is some adjustment process that makes the errors converge in the long-run.

However, because the estimated coefficients of error correction terms are significant at 5% (-2.87711) and 1% (0.56648) levels for economic growth and inflation respectively, it could be interpreted that about 46% (0.462104) of the disequilibrium is corrected each year by changes in GDP and 2% (0.023287) of the disequilibrium corrected each year by the changes in Inflation.

Estimation of the Threshold Model

To find the threshold level, we employ the equation (15) using the Threshold regression method.

Table 7: Threshold model (Dependent variable: $\Delta\, logGDP$)

K	Variable	Coefficier	Std. Erro	t-statisti	Probabili	R-square	RSS*
1%	C	19.60951	18.48840	1.060639	0.2963	0.988982	0.239964
	$\Delta LINFL$	0.061431	0.036297	1.692439	0.0997		
	D ($\Delta LINFL - k$)	0.057634	0.036392	1.583717	0.1225		
	$\Delta LGCap$	-1.759241	0.746977	-2.355140	0.0244		
	$\Delta LTTD$	0.543682	0.320057	1.698702	0.0985		
	$\Delta LPOP$	-1.049612	2.276867	-0.460989	0.6477		
2%	C	27.58061	19.65855	1.402983	0.1700	0.988424	0.237997
	$\Delta LINFL$	0.093537	0.044747	2.090358	0.0444		
	D ($\Delta LINFL - k$)	0.060095	0.041730	1.440082	0.1593		
	$\Delta LGCap$	-2.094036	0.781449	-2.679683	0.0114		
	$\Delta LTTD$	0.453341	0.336446	1.347438	0.1870		
	$\Delta LPOP$	-2.007144	2.429618	-0.826115	0.4147		
3%	C	20.79473	21.50075	0.967163	0.3407	0.985918	0.273022
	$\Delta LINFL$	0.030391	0.051086	0.594895	0.5561		
	D ($\Delta LINFL - k$)	-0.039913	0.048678	-0.819934	0.4183		
	$\Delta LGCap$	-2.215372	0.903199	-2.452805	0.0198		
	$\Delta LTTD$	0.503535	0.398393	1.263915	0.2154		
	$\Delta LPOP$	-1.108394	2.654773	-0.417510	0.6791		
4%	C	-11.27266	2.399410	-4.698090	0.0001	0.989904	0.183970
	$\Delta LINFL$	0.038727	0.044277	0.874649	0.3885		
	D ($\Delta LINFL - k$)	0.050571	0.035734	1.415191	0.1670		
	$\Delta LGCap$	-1.113636	0.203346	-5.476548	0.0000		
	$\Delta LTTD$	0.412577	0.241436	1.708842	0.0975		

	$\Delta LPOP$	2.854741	0.353994	8.064366	0.0000		
5%	C	-11.82033	2.301024	-5.136989	0.0000	0.990647	0.159772
	$\Delta LINFL$	0.034253	0.042906	0.798335	0.4310		
	D ($\Delta LINFL-k$)	0.065638	0.033882	1.937234	0.0622		
	$\Delta LGCap$	-1.287257	0.208370	-6.177745	0.0000		
	$\Delta LTTD$	0.326152	0.234428	1.391269	0.1744		
	$\Delta LPOP$	2.969980	0.341219	8.704025	0.0000		
6%	C	-11.76409	3.243497	-3.626978	0.0011	0.987428	0.200536
	$\Delta LINFL$	0.059416	0.046459	1.278886	0.2111		
	D ($\Delta LINFL-k$)	0.060021	0.037591	1.596706	0.1212		
	$\Delta LGCap$	-1.451112	0.277003	-5.238609	0.0000		
	$\Delta LTTD$	0.262352	0.276607	0.948464	0.3507		
	$\Delta LPOP$	2.999026	0.472137	6.352025	0.0000		
7%	C	18.78718	4.575391	-4.106137	0.0003	0.985953	0.208641
	$\Delta LINFL$	-0.008771	0.061615	-0.142350	0.8878		
	D ($\Delta LINFL-k$)	-0.040586	0.042323	-0.958960	0.3458		
	$\Delta LGCap$	-1.560306	0.356702	-4.374261	0.0002		
	$\Delta LTTD$	0.298618	0.317330	0.941030	0.3547		
	$\Delta LPOP$	3.924830	0.667973	5.875728	0.0000		
8%	C	-16.83407	4.038386	-4.168515	0.0003	0.988878	0.150299
	$\Delta LINFL$	0.032490	0.070050	0.463819	0.6465		
	D ($\Delta LINFL-k$)	0.004604	0.035241	0.130645	0.8970		
	$\Delta LGCap$	-1.633325	0.310268	-5.264230	0.0000		
	$\Delta LTTD$	0.177747	0.270968	0.655970	0.5174		
	$\Delta LPOP$	3.701363	0.592523	6.246781	0.0000		
9%	C	-17.10550	4.828528	-3.542590	0.0015	0.986112	0.168347
	$\Delta LINFL$	0.309276	0.134964	2.291550	0.0303		
	D ($\Delta LINFL-k$)	-0.058561	0.046659	-1.255070	0.2206		
	$\Delta LGCap$	-2.262760	0.533833	-4.238700	0.0003		
	$\Delta LTTD$	-0.418345	0.410363	-1.019451	0.3174		
	$\Delta LPOP$	3.913360	0.739530	5.291688	0.0000		
10%	C	17.20175	5.360589	-3.208929	0.0036	0.988862	0.121602

%	$\Delta LINFL$	0.140054	0.108352	1.292590	0.2080	2	2
	D ($\Delta LINFL-k$)	0.031071	0.038605	0.804843	0.4285		
	$\Delta LGCap$	-2.033581	0.643132	-3.16199	0.0041		
	$\Delta LTTD$	-0.052448	0.483272	-0.10852	0.9144		
	$\Delta LPOP$	3.840793	0.852569	4.504962	0.0001		
11%	C	-5.366507	5.524859	-0.971338	0.3391	0.956290	0.446355
	$\Delta LINFL$	-0.159797	0.108746	-1.469451	0.1521		
	D ($\Delta LINFL-k$)	0.004338	0.059338	0.073102	0.9422		
	$\Delta LGCap$	0.015607	0.395898	0.039421	0.9688		
	$\Delta LTTD$	1.562222	0.420841	3.712143	0.0008		
	$\Delta LPOP$	1.727023	0805365	2.144398	0.0402		
12%	C	-20.87982	10.79162	-1.934818	0.0654	0.987718	0.113266
	$\Delta LINFL$	0.056596	0.125812	0.449847	0.6570		
	D ($\Delta LINFL-k$)	-0.030622	0.042771	-0.71595	0.4812		
	$\Delta LGCap$	-1.932412	1.129154	-1.711381	0.1005		
	$\Delta LTTD$	0.136517	0.633898	0.215345	0.8314		
	$\Delta LPOP$	4.270967	1.641715	2.601528	0.0160		

In other to achieve the main aim of the research, the estimation of equation (15) using a RSS for threshold level of inflation between K1 to Kn percent gives a clear value of the threshold inflation level while quantifying the impact of the level of economic growth as in the table above.

Table 6 above shows the estimated result for the values of k from 1 to 12%, indicating a significant relationship between the variable of inflation and economic growth. As clearly shown, when k=6, the value of R-square is (0.942999) which kept increasing to attain a threshold at k=12 for R-square (0.852218). However, the trend showed an inverse proportion between R-square and Residual sum of squares (RSS) as seen when R-square was at its peak (0.942999) RSS attained its least point (0.909239)

Furthermore, the above table shows a result that R^2 is at max when k=6%. Also, it could be noted that the Coefficients of D($\Delta \, logINFL - k$) are significantly decreasing, when k> 6% which indicates a rate that will inhibit growth negatively. however, it could be seen that when k≤6, there seems not to be a large difference between the coefficients of D($\Delta \, logINFL - k$) which could be an indication of a stable growth.

An inflation at the threshold level will provide a safer barrier for an economy as the main aim of the central banks in developed economies is to embark on inflation targeting mechanism which helps maintain inflation at lowest (Volodymyr et al 2018) and because of the following:

i. It helps prevent the economy falling into deflation.

ii. Provide a high productivity

iii. Enhance the economy through preventing the decrease in wages.

iv. Investment could be on the increase as stable economy could increase the confidence of investors

v. Stable economy on the other hand could result to an increase in the long-run aggregate supply which could bring a high rate of economic growth.

In summary, based on the threshold level of 6% from the model, the economic growth could yield a high growth rate with future stability. This is contrary to the inflation rate that exceeds 6% which could be harmful and could as well reduce the growth of the Nigerian economy.

Summary and Conclusion

The research was aimed at determining the causal relationship between economic growth and inflation through studying the co-integrated relationship between the Economic growth and the inflation rate using the Error Correction Model. In achieving this aim, the need to determine the relationship between the two variables, the type of relationship as well the effect of this relationship on the Nigerian economy cannot be overemphasized.

As shown in the result of the paper, there is a positive long-run relationship between the two variables which deems a linear relationship. Linear relationship denotes a direct proportion as could be mathematically. However, it is inevitable to find out at what level this linearity could harm the economy. To achieve this objective, the threshold regression was employed to determine the threshold level of inflation on the Nigerian economy over the period of study.

The result reveals that at above 6% level of Inflation, the Nigerian economy will tend to decline. Contrary to this, the economy will stabilize or improve when the inflation rate is 6% or below 6% respectively. This level is in support of the work of (Kremer, Bick & Nautz, 2013) and (Espinonza, Leon & Prasad, 2010) both came to the conclusion that an inflation level of between 10 – 17% will not trigger much of instability for developing economies. Also, the work of Khan and Senhadji (2001) and Vaona (2012) both supported the notion that a 1% and 11% inflation threshold increase will not undermine both developed and developing economies respectively.

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