ECO-ENA: Economics & ECO-Engineering Associate, Inc.®, Canada

**The Annual Conference of Economic Forum of Entrepreneurship &
International Business
ACEFEIB**

The 9th Annual Conference of the Economic Forum of Entrepreneurship &
International Business

February 1st, 2023

Venue: LMH, University of Oxford, Oxford, United Kingdom

2023

The 9th Annual Conference of the Economic Forum of Entrepreneurship & International Business

February 1st, 2023

<u>**Venue:**</u> LMH, University of Oxford, Oxford, United Kingdom

Conference Proceeding

ECO-ENA, Inc.
www.eco-ena.ca

ECO-ENA: Economics & ECO-Engineering Associate, Inc., Canada

2023

The 9th Annual Conference of Economic Forum of Entrepreneurship & International Business

February 1st, 2023

Venue: LMH, University of Oxford, Oxford, United Kingdom

Editors

Ghana G. Mohamed

Morrison H. Schachler

Daniel May

Thomas Henschel

ECO-ENA: Economics & ECO-Engineering Associate, Inc.®, Canada
www.eco-ena.ca

The Annual Conference of Economic Forum of Entrepreneurship & International Business
(ACEFEIB)

The 9th Annual Conference of Economic Forum of Entrepreneurship & International Business

February 1st, 2023

Venue: LMH, University of Oxford, Oxford, United Kingdom

Conference Chairs

Ghana Mohamed, Handley-Schachler, Daniel May, and Thomas Henschel

Conference Organizer

Dr. Ghada Gomaa A. Mohamed
ECO-ENA, Inc., Canada
gmohamed@eco-ena.ca

Sponsored by:

ECO-ENA: Economics & ECO-Engineering Associate, Inc.®, Canada

Acknowledgements

ECO-ENA, Inc.® would like to thank all staff of Lady Margaret Hall, University of Oxford for their great hospitality during the conference.

ECO-ENA, Inc.® would like to thank all participants at the conference.

ECO-ENA, Inc. ® Organizing team

ECO-ENA: Economics & ECO-Engineering Associate, Inc.®

The 9th Annual Conference of Economic Forum of Entrepreneurship & International Business - (NACEFEIB)

<u>Conference Reporting</u>

A Hybrid Event
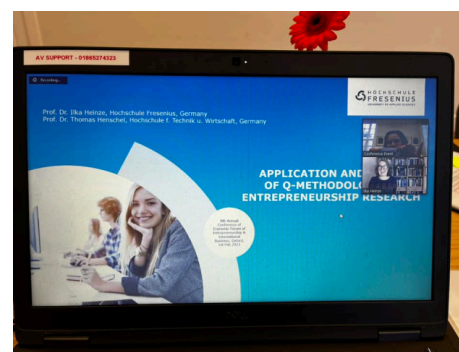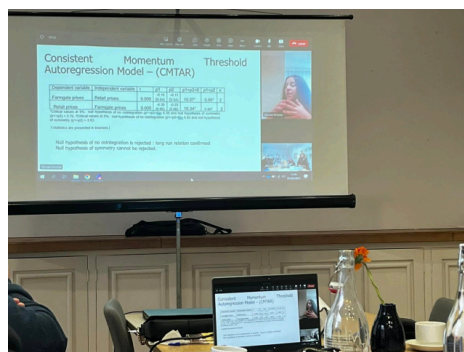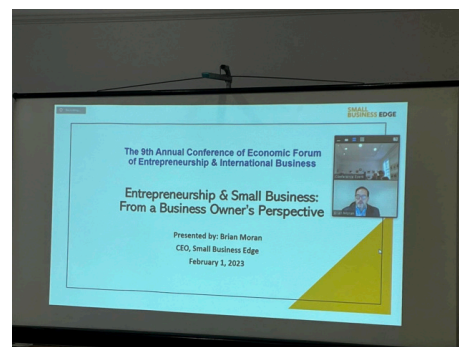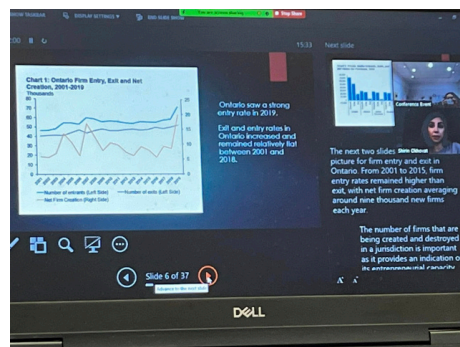
Presenters

[Thomas Henschel](), Professor, Hochschule fur Technik und Wirtschaft, Berlin, Germany and Visiting Professor, Verona University, Italy

[Ilka Heinze](), Professor, Hochschule Fresenius, Germany

Paper: *"The application and the value of the Q-Method in entrepreneurship"* - *Presentation*

Abdulmalik Sadiq, Ph.D. Candidate, Cracow University of Economics, Germany

Paper: *"Inflation and Economic Growth: An analysis of the inflation threshold level of the Nigerian economy"* - *Presentation*

Shirin Okhovat, Senior Economist, Ministry of Finance, Canada

Paper: *"Applying Machine Learning and a Dynamic Logit Panel in Modeling the Turnover Behaviour of Firms in Ontario"* - *Presentation*

Julia Yereshko, Professor, Technische Universität München - Institute for Advanced Study, Germany
Iryna Kreidych, Professor, National Technical University of Ukraine, Ukraine

Paper: "*UPDATING THE UKRAINIAN VENTURING MODEL*" - *Presentation*

A keynote speech over zoom by **Brian Moran**, CEO of Small Business Edge, USA
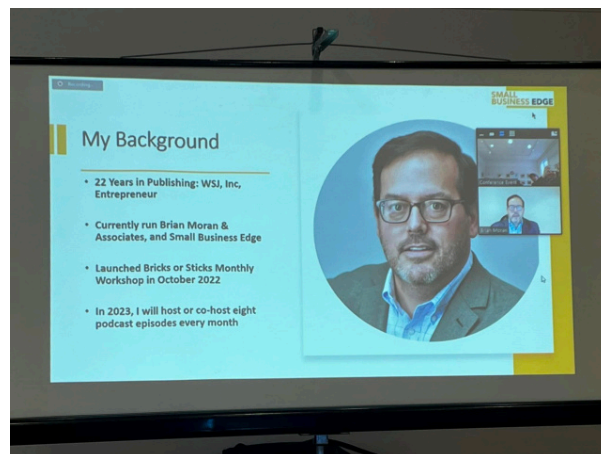
"Entrepreneurship & Small Business" from an entrepreneur's view - Presentation

Tremma Ourania, Senior Lecturer, Harper Adams University, UK
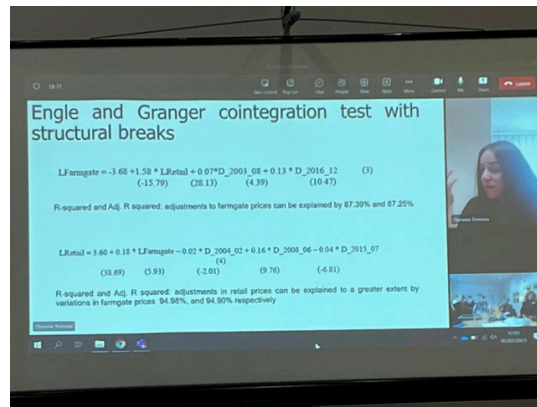
Paper: "*Price Interrelations in the UK milk Supply Chain*"

Co-authors: Hall Grace and De Aguiar Luis (Harper Adams University)

Morrison Handley-Schachler (UK), Vice-president of Research, ECO-ENA, Canada

Paper: "*Fraud and Misappropriation of Assets: Control and Mitigation"* - *Presentation*

Daniel May, Senior Lecturer, Harper Adams University, United Kingdom

Paper: "*Identifying past economic organization through the rural landscape*" - *Presentation*

Ghada Gomaa A. Mohamed, President, ECO-ENA, Canada & Professor & Dean of Students, Forward Academy (USA/ Middle East)
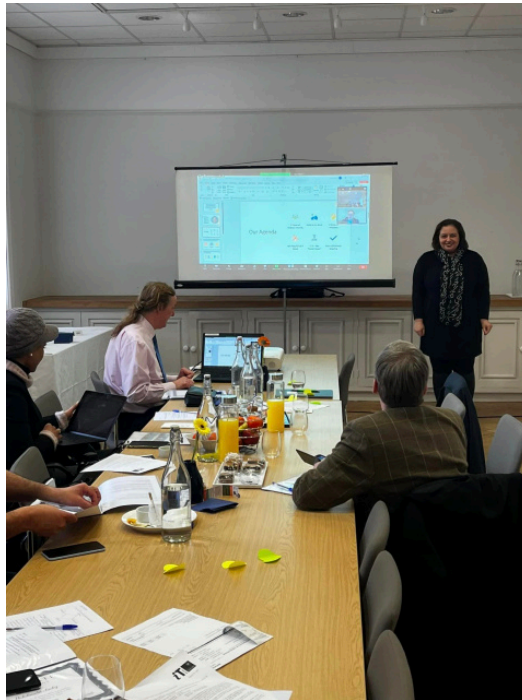
Paper: "*Food Security & Consumer Behavior - A Quantifying Approach*" - *Presentation*

An attendee: **Raghad Alsurayh**i (In person), University of Sussex, United Kingdom

Conference Program

8:30 am - 6:00 pm

The Jerwood Room

Duration of each presentation session: 35-45 minutes + 10-15 minutes of discussion

8:30 am - 9:00 am: Registration and Refreshments

Session I

9:00 am - 12::30 pm

The 1st presentation: 9:00 am to 10:00 pm - Including open discussion

Thomas Henschel, Professor, Hochschule fur Technik und Wirtschaft, Berlin, Germany and
Visiting Professor, Verona University, Italy

Ilka Heinze, Professor, Hochschule Fresenius, Germany
Paper: "The application and the value of the Q-Method in entrepreneurship"

The 2nd presentation: 10:00 am to 11:00 pm - Including open discussion

Julia Yereshko, Professor, Technische Universität München - Institute for Advanced Study, Germany
Iryna Kreidych, Professor, National Technical University of Ukraine, Ukraine, Ukraine
Paper: "UPDATING THE UKRAINIAN VENTURING MODEL"

The 3rd presentation: 11:00 am to 11:50 - Including open discussion

Abdulmalik Sadiq, Ph.D. Candidate, Cracow University of Economics, Germany
Paper: "Inflation and Economic Growth: An analysis of the inflation threshold level of the Nigerian economy"

The 4th presentation: 11:50 am to 12:30 - Including open discussion

Tremma Ourania, Senior Lecturer, Harper Adams University, UK - Via zoom

Paper: "Price Interrelations in the UK milk Supply Chain"

Lunch Break - All delegates are invited

12:30 - 1:30 pm

Session II

1:30 - 3:30 pm

The 5th presentation: 1:30 pm to 2:20 pm - Including open discussion

Morrison H. Schachler (UK), Vice-president of Research, ECO-ENA, Canada
Paper: "Fraud and Misappropriation of Assets: Control and Mitigation"

The 6th presentation: 2:20 pm to 3:00 pm - A Keynote Speech - Via zoom

Brian Moran, CEO of Small Business Edge, USA

"Entrepreneurship & Small Business" from an entrepreneur's view

The second coffee break - with a panel discussion

3:00 - 3:30 pm

Session III

3:30 - 6:00 pm

The 7th presentation: 3:30 pm to 4:20 pm - Including open discussion

Shirin Okhovat, Senior Economist, Ministry of Finance, Canada - Via zoom
Paper: "Applying Machine Learning and a Dynamic Logit Panel in Modeling the Turnover Behaviour of Firms in Ontario"

The 8th presentation: 4:20 pm to 5:00 pm - Including open discussion

Daniel May, Senior Lecturer, Harper Adams University, United Kingdom
Paper: "Identifying past economic organization through the rural landscape"

The 9th presentation: 5:00 pm to 5:40 pm - Including open discussion

Ghada Mohamed, President, ECO-ENA, Canada & Professor & Dean of Students, Forward Academy (USA/ Middle East)
Paper: "Food Security & Consumer Behavior - A Quantifying Approach"

5:40 - 6:00 pm

Closing by the conference chair

Conference Dinner Gathering

All delegates are invited - Zizzi Italian Restaurant, Oxford

Abstracts

Paper: "Inflation and Economic Growth: An analysis of the inflation threshold level of the Nigerian economy"
Author: Sadiq Abdulmalik
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.

Paper: *"UPDATING THE UKRAINIAN VENTURING MODEL"*
Authors: Julia Yereshko, Hanna Hottenrott, Maryna Kravchenko , and Iryna Kreidych
Abstract: Even before the russian invasion, the lack of funding for innovation remained the main obstacle to economic and technical development of Ukraine. Mainly due to a number of reasons: from historical to geopolitical, and currently the situation is only being aggravated. Despite the fact that the venture capital industry was established in Ukraine in the early 1990s, it has not received significant proliferation and effectiveness. The reason lies for the most part in the specifics of legislation, as well as the historical features of governance which are a hidden reason for slowing down the innovation and investment. Thus, the purpose of this research is to update the Ukrainian venturing model, taking into account the peculiarities of the economy, governance, aftermath of war and nation's future development patterns and opportunities. A preliminary analysis of the Ukraine's pre-war venture model serves as the basis for a deeper investigation of the feasibility of a combination of public, private and research components of the investment process, i.e., the need to involve universities and research institutions into the venture industry. We document that pre-war venture investment in Ukraine was a distorted model of global venture business, designed to generate excess profits for financial and industrial groups, holdings and corporations. We propose to re-design it from the standpoint of previously substantiated conclusions. In addition, we stress the importance of reforming the relevant legislation in order to shift the focus of venture capital institutions on innovation, as opposed to financing financial-industrial groups, agriculture and commerce.

Paper: "Examining price co-movements in major EU pork markets"

Authors. Ourania Tremma and Pamela Theofanous

Abstract: The present study examines price linkages between the major EU pork markets and evaluates the efficiency of the market. This is achieved with data derived from the European Commission database representing monthly wholesale prices for Spain, France and Germany covering the period 2003-2022. The non-linear causality test of Diks and Panchenko (2006) is employed to determine the causal markets and to form the examined price pairs. Moreover, the bootstrap causality test of Hacker and Hatemi (2010) is used to further validate the findings. The long and short run relations are examined using the Momentum Threshold Model accounting for asymmetries in the process. The findings confirm that the price pairs are cointegrated suggesting that the EU pork market is indeed integrated and results show that the Law of One price holds for the examined pairs. In addition, asymmetries are found in few cases in the short run, a finding which may be explained by market power achieved through high concentration. In this respect, the study emphasises that overall the EU pork market is efficient and indicates the success of the policies raised.

Paper: *"Fraud and Misappropriation of Cryptocurrency Assets"*

Authors: Norazida Mohamed, Syakir Che Saruji, Akhbar Satar, **Morrison Handley Schachler** and Nasir Sultan

Abstract: The research uses the framework of the fraud diamond to analyse four cases of misappropriation of cryptocurrency assets between 2010 and 2023. The fraud diamond has four angles: pressure, opportunity, rationalization and capability. The fact that the existence of cryptocurrency assets is entirely based on electronic records is in theory an obstacle to the undetected misappropriation of assets and the laundering of stolen assets. However, this only reduces but does not eliminate opportunities for misappropriation and has no effect on pressures, rationalizations and capability. The reliance on electronic recording systems as part of a system of control and accountability is not sufficient in itself to prevent asset misappropriation. Factors affecting capability are highly significant in the prevention of cryptocurrency thefts and are strongly related to the ability of cryptocurrency thieves to recruit willing conspirators and accessories to help with the theft and laundering of the assets. Capability and pressure can also arise from the ownership or management of other businesses by the managers of cryptocurrency exchanges, giving rise to an inherent risk of fraudulent behaviour. Because frauds may be committed by those who are responsible for the design and implementation of control systems, it is especially important that regulators and auditors take cognizance of these inherent risks in conducting their work.

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

Author: 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.

Paper: *"Identifying past economic organization through the rural landscape"*
Author: Daniel May
Abstract: The landscape is an important storage of information about the economic and social organisation in the past. It is considered a palimpsest that ca be read from indirect sources. This article explores the region of Gloucestershire region in the UK to identify how people in Roman times organised their economic activity in this landscape. Using the ArGis software, it was found that archaeological sites are located near Roman roads and in places associated with low human body effort and energy consumption. This suggests that economic activity was carried out in areas of good accessibility, and they traded their goods in a wide trade network.

Paper: *"Food insecurity, consumer behaviour, social welfare, sustainability*
A quantifying approach"
Author: Ghana G. Mohamed
Abstract: This manuscript provides a mathematical approach to measuring food security, linking it mathematically to the concept of social welfare over time to figure out the impact of food security on the transitional dynamism of social welfare. The utilized mathematical approach in this manuscript is essential as a foundation for further research on food insecurity/ security, consumer behaviour, and social welfare over time.

Selected Manuscripts

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

Author Contact Details: Shirin Okhovat, Senior Economist, Ministry of Finance, Canada.

Email: shirin.okhovat@ontario.ca

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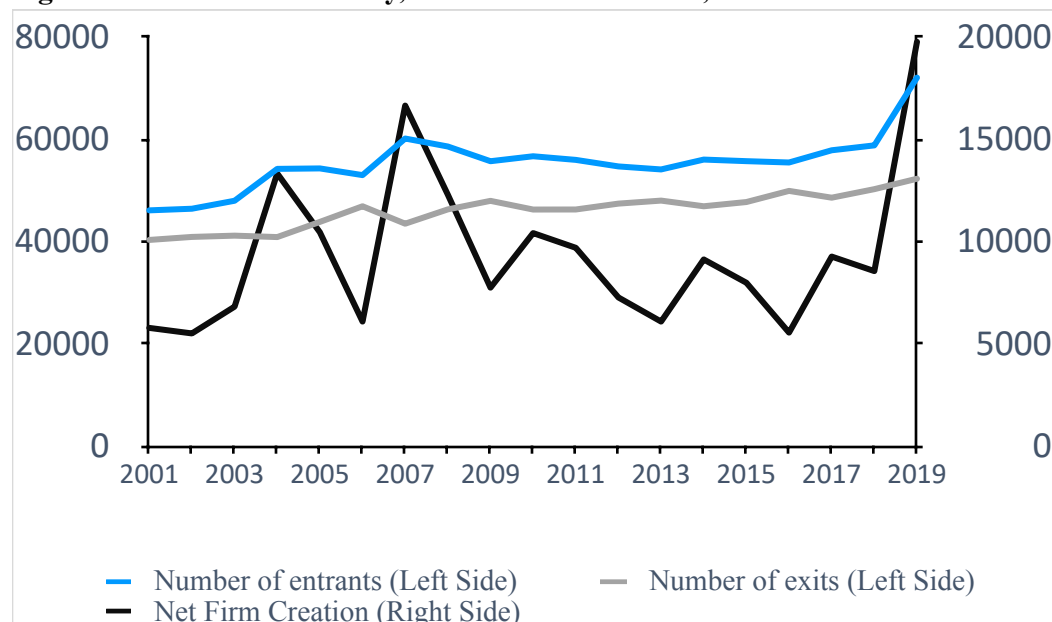
A noteworthy observation was made in 2019, as Ontario recorded a marked increase in net firm creation compared to all other provinces and territories. This trend is demonstrated in Chart 2.

Figure 2: Private Sector Entrants, Exits, and Net Values for Provinces, 2019
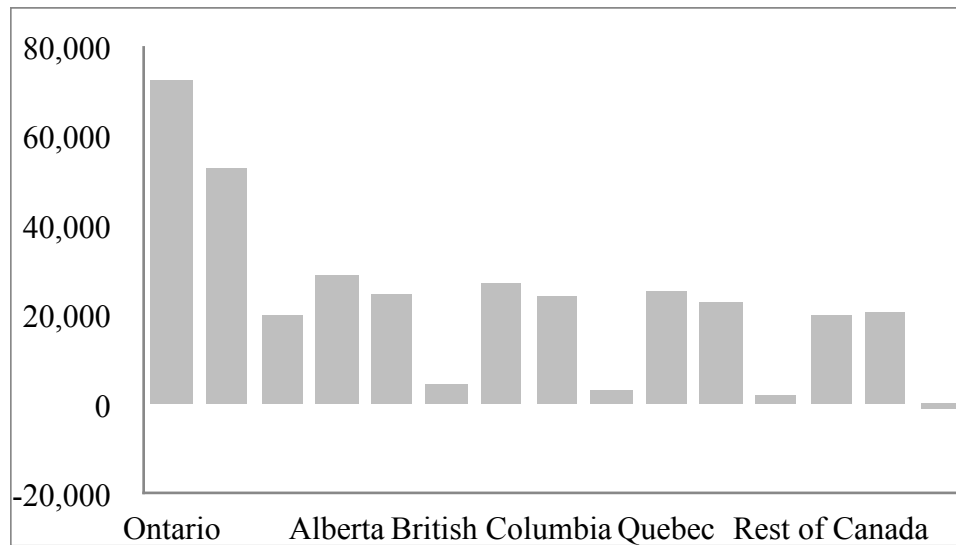
3. Location Theories and Factors Influencing Firm Delocalization

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:

$$E_i = \alpha B_r + \beta Y_i + \varepsilon_i$$

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 incorporation*
NAICS	*North America Industry Classification System code*
MPP_CR	*Manufacturing and Processing Credit amount claimed*
LAND	*The value of land owned by a corporation*
DEPL_ASSETS	*Depletable assets*
AMM_DEPL_ASSETS	*Accumulated amortization of depletable assets*
BUILDINGS	*Buildings*
AMM_BUILDINGS	*Accumulated amortization of buildings*
MACHINERY	*Machinery, equipment, furniture, and fixtures*
AMM_MACHINERY	*Accumulated amortization of machinery, equipment, furniture, and fixtures*
OTHER_TAN_CAP_ASSETS	*Other tangible capital assets*
AMM_OTHER_TAN_CAP_ASSET	*Accumulated amortization of other tangible capital assets*

TOT_TANG_ASSETS	*Total tangible capital assets*		
AMM_TOT_TANG_ASSETS	*Accumulated amortization of total tangible capital assets*		
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:

$$Exit_{it}=a+b*age_{it}+c*Sunk_{it}+d*Typecorp_{it}+e*Foreignsubcount_{it}+f*Avewage_{it}+g*Foreginparentco$$

$$unt_{it}+H*Intgrow_{it}+I*Size_{it}+error\text{-}it$$

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.
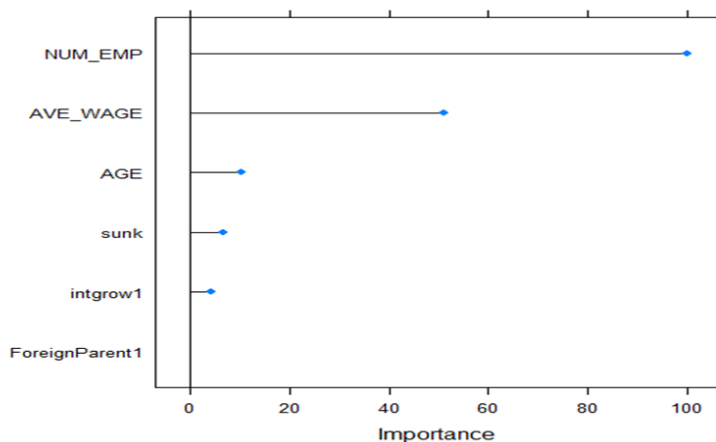
The results of the study indicate that the key determinants of a firm's turnover behavior, as indicated by a Random Forest Decision Tree (RFDT) Importance Chart, are the combination of employment size and average wage, the total value of tangible assets, the age of the firm, and the nationality-foreign 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 $X\beta$) 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.

References

Abdollahnejad, A., Panagiotidis, D., Joybari, S.S. and Surovỳ, P. (2017). Prediction of dominant forest tree species using quickbird and environmental data. Forests, 8(2). https://doi.org/10.3390/f8020042

An, Y., Kang, Y. and Lee, S. (2014). A study on the impact of soft location factors in the relocation of service and manufacturing firms. International Journal of Urban Science, 18(3), pp.327-339. https://doi.org/10.1080/12265934.2014.893834

Baggs, J., Beaulieu, E. and Fung, L. (2009). Firm survival, performance, and the exchange rate. Canadian Journal of Economics, 42(2), pp.393-421. https://doi.org/10.1111/j.1540-5982.2009.01513.x

Brouwer, A.E., Mariotti, I. and van Ommeren, J.N. (2004). The firm relocation decision: An empirical investigation. Annals of Regional Science, 38(2), pp.335-347. https://doi.org/10.1007/s00168-004-0198-5

Cao, S. and Leung, D. (2010). Labour reallocation, relative prices and productivity.

Carey, D., Lester, J. and Luong, I. (2016). Boosting productivity through greater small business dynamism in Canada. Report No. 1314. https://dx.doi.org/10.1787/5jlv23k891r8-en

Ciaramella, A. and Dettwiler, P. (2011). A relocation model of European manufacturing firms: cases from Italy and Sweden. Journal of Corporate Real Estate, 13(4), pp.233-246. https://doi.org/10.1108/14630011111214437

Clementi, G.L. and Palazzo, B. (2013). Entry, exit, firm dynamics, and aggregate fluctuations. NBER Working Paper No.19217. https://doi.org/10.3386/w19217

Cumming, D., Fleming, G. and Schwienbacher, A. (2009). E T & P Venture Capital Finance. Entrepreneurship Theory and Practice, 33(5), pp.1121-1155. https://doi.org/10.1111/j.1540-6520.2009.00337.x

Gu, W. and Li, J. (2017). Analytical Studies Branch Research Paper Series Multinationals and Reallocation: Productivity Growth in the Canadian Manufacturing Sector.

Horton, J.J. (2017). Price Floors and Employer Preferences: Evidence from a Minimum Wage Experiment. SSRN. https://doi.org/10.2139/ssrn.2898827

Howell, S.T. (2017). Financing innovation: Evidence from R&D grants. American Economic Review, 107(4), pp.1136-1164. https://doi.org/10.1257/aer.20150808 Huynh KP, Ostrovsky Y, Petrunia RJ, Voia MC. (2017) Industry shutdown rates and permanent layoffs: evidence from firm-worker matched data. IZA Journal of Labor Economics, 6(1). https://doi.org/10.1186/s40172-017-0057-0

Hyslop DR, Maré DC, Stillman S, Timmins J. (2012) Heterogeneous Firm Responses to Rising Teenage Wages. Labour, 26(4), 436-454. https://doi.org/10.1111/labr.12000

Johdo W. (2010) Profit Taxation, Monopolistic Competition and International Relocation of Firms. Seoul Journal of Economics, 23(3), 365-389.

Johnson BND, Lafountain CL, Yamarik S. (2009) Working Paper. North.

Kronenberg K. (2013) Firm relocations in the Netherlands: Why do firms move, and where do they go? Papers in Regional Science, 92(4), 691-713. https://doi.org/10.1111/j.1435-5957.2012.00443.x

Lehmann R, Wohlrabe K. (2014) Regional economic forecasting: state-of-the-art methodology and future challenges. Economics & Business Letters, 3(4), 218-231.

Leung D, Macdonald R, Researcher P, Division EA. (2017) Firm size and economic performance.

Longhi S, Nijkamp P, Reggianni A, Maierhofer E. (2005) Neural Network Modeling as a Tool for Forecasting Regional Employment Patterns. International Regional Science Review, 28(3), 330-346. https://doi.org/10.1177/0160017605276187

Luca DL, Luca M. (n.d.) Survival of the Fittest: The Impact of the Minimum Wage on Firm Exit.

Maoh HF. (2005) Modeling firm demography in urban areas with an application to Hamilton, Ontario: Towards an agent-based microsimulation model. http://digitalcommons.mcmaster.ca/dissertations/AAINR07917.

Marinoiu C. (2015) Selecting the Best Model to Forecast Romanian Employment in Industry, 5(2), 53-61.

Moeckel R. (2013) Employment Location in Cities and Regions, 223-242. https://doi.org/10.1007/978-3-642-31779-8

Muñoz-Bravo S, Pérez-Méndez A, Rivas-Echeverría F. (2009) Artificial neural network model for estimating the female and male population in working age in Venezuela. WSEAS Transactions on Business and Economics, 6(4), 177-188.

Patuelli, R., Longhi, S., Reggiani, A., Nijkamp, P., & Blien, U. (2007). A rank-order test on the statistical performance of neural network models for regional labor market forecasts. Regional Studies, 37(1), 64-81. https://libproxy.library.unt.edu:9443/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=32797783&site=ehost-live&scope=site.

Patuelli, R., Reggiani, A., & Nijkamp, P. (2006). The development of regional employment in Germany: Results from neural network experiments. Neural Networks, 1(3), 1-23.

Patuelli, R., Reggiani, A., Nijkamp, P., & Schanne, N. (2011). Neural networks for regional employment forecasts: Are the parameters relevant? Journal of Geographical Systems, 13(1), 67-85. https://doi.org/10.1007/s10109-010-0133-5

Pellenbarg, P. H. (2005). Firm migration in the Netherlands. 45th ERSA Congress, (August), 1-24. https://doi.org/10.1007/s10273-011-1262-2

Rasmussen, E., Jensen, J. M., & Servais, P. (2011). The impact of internationalization on small firms' choice of location and propensity for relocation. Journal of Small Business and Enterprise Development, 18(3), 457-474. https://doi.org/10.1108/14626001111155664

Sajid, M. R. (2011). Determinants of labor force participation of married women: A case study of district Gujrat, 1(3), 254-264.

Shanlang, L. (2011). The spatial allocation of factors, factor mobility and agglomeration of information service industry.

Stasinakis, C., Sermpinis, G., Theofilatos, K., & Karathanasopoulos, A. (2016). Forecasting US unemployment with radial basis neural networks, Kalman filters and support vector regressions. Computational Economics, 47(4), 569-587. https://doi.org/10.1007/s10614-014-9479-y

Van Dijk, J., & Pellenbarg, P. H. (2000). Firm relocation decisions in the Netherlands: An ordered logit approach. Papers in Regional Science, 79(2), 191-219. https://doi.org/10.1007/s101100050043

Zeigermann, L. (n.d.). Opencagegeo: Stata module for geocoding, 1-10.Countries strategic issues for Italian companies active in the retail & consumer sector.

Pellenbarg, P. (n.d.). Firm migration (Industrial Location Economics).

Davidsson, P., Lindmark, L., & Olofsson, C. (1994). New firm formation and regional development in Sweden. Regional Studies, 28(4), 395-410. https://doi.org/10.1080/00343409412331348356 Gordon, I. R., & McCann, P. (2005). Innovation, agglomeration, and regional development. Journal of Economic Geography, 5(5), 523-543. https://doi.org/10.1093/jeg/lbh072

Georgopoulos, G. (2009). Measuring regional effects of monetary policy in Canada. Applied Economics, 41(16), 2093-2113. https://doi.org/10.1080/00036840701604362

Cheng, S. (2011). Business cycle, industrial composition, or regional advantage? A decomposition analysis of new firm formation in the United States. Annals of Regional Science, 47(1), 147-167. https://doi.org/10.1007/s00168-009-0361-0

Bishop, P. (2012). Knowledge, diversity and entrepreneurship: A spatial analysis of new firm formation in Great Britain. Regional Studies, 24(7-8), 641-660. https://doi.org/10.1080/08985626.2011.617786

Bishop, P., & Brand, S. (2014). Human capital, diversity, and new firm formation. Service Industries Journal, 34(7), 567-583. https://doi.org/10.1080/02642069.2014.886193

Müller, S. (2016). A progress review of entrepreneurship and regional development (European Planning Studies). European Planning Studies, 24(6), 1133-1158. https://doi.org/

Calá, C. D., Manjón-Antolín, M., & Arauzo-Carod, J. M. (2016). Regional determinants of firm entry in a developing country. Papers in Regional Science, 95(2), 259-279. https://doi.org/10.1111/pirs.12128

Piacentino, D., Bono, F., Cracolici, M. F., & Giuliani, D. (2017). A spatial analysis of new business formation: Replicative vs innovative behaviour. Spatial Statistics, 21, 390-405. https://doi.org/10.1016/j.spasta.2017.02.004

Bishop, P., & Shilcof, D. (2017). The spatial dynamics of new firm births during an economic crisis: the case of Great Britain, 2004–2012. Entrepreneurship & Regional Development, 29(3-4), 215-237. https://doi.org/10.1080/08985626.2016.1257073

Breitenecker, R. J., Harms, R., Weyh, A., Maresch, D., & Kraus, S. (2017). When the difference makes a difference–the regional embeddedness of entrepreneurship. Entrepreneurship & Regional Development, 29(1-2), 71-93. https://doi.org/10.1080/08985626.2016.1255432

Schölin, T., Ohlsson, H., & Broomé, P. (2017). The role of regions for different forms of business organizations. Entrepreneurship & Regional Development, 29(3-4), 197-214. https://doi.org/10.1080/08985626.2016.1257072 Weterings, A., & Knoben, J. (2013). Footloose: An analysis of the drivers of firm relocations over different distances. Papers in Regional Science, 92(4), 791-809. https://doi.org/10.1111/j.1435-5957.2012.00440.x

Delocalisation of production: Threats and opportunities for Estonia. (n.d.). Abstract.

Kilvits, K. (n.d.). Delocalisation of Industries and the Role of Governing Institutions with Evidenced from Estonia 1 Introduction.

Kapitsinis, N. (2017). Firm relocation in times of economic crisis: evidence from Greek small and medium enterprises' movement to Bulgaria, 2007–2014. European Planning Studies, 25(4), 703-725. https://doi.org/10.1080/09654313.2017.1288703

Nguyen, C. Y., Sano, K., Tran, T. V., & Doan, T. T. (2013). Firm relocation patterns incorporating spatial interactions. Annals of Regional Science, 50(3), 685-703. https://doi.org/10.1007/s00168-012-0523-3

Kronenberg, K. (2013). Firm relocations in the Netherlands: Why do firms move, and where do they go? Papers in Regional Science, 92(4), 691-713. https://doi.org/10.1111/j.1435-5957.2012.00443.x

Labrianidis, L., & Vogiatzis, N. (2011). Local Delocalization across Borders: The Case of the Garment Quasi-Cluster in the Balkans. Journal of Borderland Studies, 26(1), 35-51. https://doi.org/10.1080/08865655.2011.590286

Mazzanti, M., Montresor, S., & Pini, P. (2011). Outsourcing, delocalization and firm organization: Transaction costs versus industrial relations in a local production system of Emilia Romagna. Entrepreneurship & Regional Development, 23(7-8), 419-447. https://doi.org/10.1080/08985620903233986

Risselada, A., Schutjens, V., & Van Oort, F. (2013). Real estate determinants of firm relocation in urban residential neighbourhoods. Tijdschrift voor Economische en Sociale Geografie, 104(2), 136-158. https://doi.org/10.1111/tesg.12010

Sleutjes, B., & Völker, B. (2012). The role of the neighbourhood for firm relocation. Tijdschrift voor Economische en Sociale Geografie, 103(2), 240-249. https://doi.org/10.1111/j.1467-9663.2012.00713.x

Henrickson, K. E. (2012). Spatial competition and strategic firm relocation. Economic Inquiry, 50(2), 364-379. https://doi.org/10.1111/j.1465-7295.2010.00302.x

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

Author Contact Detail: Abdulmalik Sadiq, Cracow University of Economics, Germany. cidix05@gmail.com

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)

$\pi=\delta R/M$ ……………………………………………………………………… *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 $\pi = \dfrac{1}{p}$

$$\frac{1}{p}=\delta\frac{R}{M}$$ …………………………………………………………………*2.*

Or

$$p = \frac{M}{\delta R}$$ …………………………………………………………………*3*

49

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:

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

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

$$Y * \frac{t}{Y(t)} Growth rate of output$$

$$L * \frac{t}{L(t)} Growth rate of Labor$$

$$K * \frac{t}{K(t)} Growth rate of Capital$$

$\alpha k(t)-$ 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 $\left(Y = \dfrac{dlog(yt)}{dt}\right)$, $\theta f'(Kt, Lt)$ is the marginal productivity of capital, I is the investment rate, $\left(\dfrac{1}{Y}\right)\left(\dfrac{dK}{dt}\right)$.

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 **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:

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

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

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:

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

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

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 ($logGDPt$ and $logINFLt$) 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:

$$\Delta logGDP_t = \beta 0 + \beta 1 (\Delta logINFL_t) + \beta 2 * D_t (\Delta logINFL_t - k) + \beta 3 (\Delta logGCap_t) + \beta 4 (\Delta logTTD_t) + \beta 5 (\Delta logPOP_t) + E_t$$

……………………………………………………. 15

Δ denotes 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 $\Delta logINFL_t > k$; Dt=0 if $\Delta logINFL_t \leq k$.

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
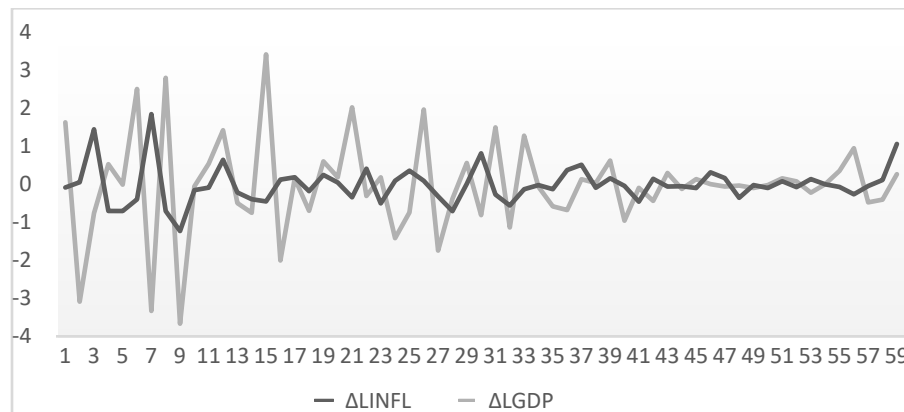
Test for stationarity

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 F (Intercept)	ADF (Intercept and trend)	PP (Intercept)	PP (Intercept and trend)	K P S S (Intercept)	K P S S (Intercept and trend)
logGDP	-1.099523(0)	-1.602997(0)	-1.119658(3)	-1.823691(3)	1.318781(3)	0.143158(3)
logINFL	-4.014721(1)***	-4.473874(1)***	-3.775028(3)***	-4.126876(3)***	0.526105(3)	0.239026(3)
logMoney	-2.155846(0)	-2.595429(0)	-2.277094(1)	-2.754516(1)	0.457529(5)	0.123315(5)
$\Delta logGDP$	-6.357625(0)***	-6.328946(0)***	-6.338376(3)***	-6.307223(3)***	0.098259(3)*	0.079940(3)*
$\Delta logINFL$	-5.836660(3)***	-5.983537(5)***	-9.745568(3)***	-9.632340(3)***	0.058746(3)**	0.051747(3)***
$\Delta logMoney$	-6.976827(0)***	-6.913535(0)***	-7.152315(6)***	-7.067044(6)***	0.063027(5)**	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 (Intercept)	ADF (Intercept and trend)	PP (Intercept)	PP (Intercept and trend)	K P S S (Intercept)	KPSS (Intercept 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)
LogMoney	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-Fuller	**Phillip-Perron**
0.416970	2.845474(1)*	2.600608(3)*
Coefficient of logGDP	Unit Root Tests for the Residual, μt	
	Augmented Dickey-Fuller	**Phillip-Perron**
0.908324	1.687082(0)***	-1.602997(3)
Coefficient of logMoney	**Augmented Dickey-Fuller**	**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 Value	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 Value	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).

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

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

Table 6: Error Correction Model

Error Correction	$\Delta logGDP$	$\Delta logINFL$	$\Delta logMoney$
Constant	0.427112	-1.326360	-0.193771
	(0.25191)	(1.07487)	(0.19529)
	[1.69552]	[-1.23397]	[-0.99224]

$\Delta logGDP_{(-1)}$	1.169072	0.319418	0.085509
	(0.14454)	(0.61676)	(0.11205)
	[8.08802]	[0.51790]	[0.76310]
$\Delta logGDP_{(-2)}$	-0.237865	-0.155277	-0.029479
	(0.14033)	(0.59879)	(0.10879)
	[-1.69501]	[-0.25932]	[-0.27097]
$\Delta logINFL_{(-1)}$	0.017656	0.618757	-0.034702
	(0.03239)	(0.13823)	(0.02511)
	[0.54501]	[4.47637]	[-1.38179]
$\Delta logINFL_{(-2)}$	0.002968	-0.182297	0.006451
	(0.03265)	(0.13932)	(0.02531)
	[0.09091]	[-1.30847]	[0.25484]
$\Delta logMoney_{(-1)}$	0.471949	1.182744	0.902037
	(0.18930)	(0.80775)	(0.14675)
	[2.49308]	[1.46425]	[6.14658]
$\Delta logMoney_{(-2)}$	-0.199914	-1.073947	-0.225462
	(0.19900)	(0.84913)	(0.15427)
	[-1.00459]	[-1.26477]	[-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: $\Delta \log GDP$)

K	Variable	Coefficient	Std. Error	t-statistics	Probability	R-squared	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	-2.355146	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	-4.698096	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	-0.958966	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	-1.255076	0.2206		
	$\Delta LGCap$	-2.262760	0.533833	-4.238706	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		
	D ($\Delta LINFL - k$)	0.031071	0.038605	0.804843	0.4285		
	$\Delta LGCap$	-2.033581	0.643132	-3.161994	0.0041		

	$\Delta LTTD$	-0.052448	0.483272	-0.108526	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	-0.715950	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.

References

Ahmed, H.L., and Zaid, S.A., (2016), "Inflation and Economic: An estimate of the threshold level of inflation in the U.S.". Ver. II. Journal of Economics and Finance, 7(6), 23-34.

Ahmed, S., and Mortaza, G., (2005), "Inflation and Economic Growth in Bangladesh:1981- 2005". Policy Analysis Unit (PAU) Working Paper 0604.

Akaike, H., 1973. "Information theory and the extension of the maximum likelihood principle", in B.N. Petrov and F. Csaki, eds., Proceedings of the Second International Symposium on Information Theory, Budapest, pp. 267-281.

Barro, Robert, (1995), "Inflation and Economic Growth", NBER Working Paper, 5326.

Benabou, R., Konieczny, J.D., (1994), "On Inflation and output with costly price changes: A simple unifying result. American Economic Review, 84(1), 290-297.

Bhatia, Rattan J., (1960), "Inflation, Deflation, and Economic Development", IMF Staff Papers, Vol. 8, no. 1, pp. 101–14.

Bruno, M. and Easterly, W., (1998), "Inflation Crises and Long-Run Growth". Journal of Monetary Economics, 41, pp. 3-26.

Christoffersen, P. and Doyle, P., (1998), "From Inflation to Growth. Eight Years of Transition", IMF Working Paper No. WP/98/100.

Clark, T.E., (1997), "Cross-country Evidence on Long-run Growth and Inflation," Economic Inquiry 35, pp. 70-81.

De Gregorio, José, (1992), "Effects of Inflation on Economic Growth: Lessons from Latin America". European Economic Review, Vol. 36 (April), pp. 417–25.

De Gregorio, José, (1996), "Inflation, Growth and Central Banks", The World Bank, Policy Research Working Paper 1575.

Dickey, D.A. and Fuller, W.A., (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root". Econometrica, Vol. 49, pp. 1057-1072.

Dmaziger, L. (1988), Costs of price adjustment and the welfare economics of inflation and disinflation. American Economic Review, 78(4), 633-646.

Dornbusch, R., Fischer, S., Kearney, C. (1996), Macroeconomics. Sydney: The Mc-Graw-Hill Companies, Inc.

Dornbusch, R., Stanley, F. (1993), Moderate Inflation. National Bureau of Economic Research Working Paper Series No. 3896. The World Bank Economic Review, 7(1), 1-44.

Dorrance, S., (1963), "The Effect of Inflation on Economic Development", Staff Papers, International Monetary Fund, Vol. 10, pp. 1-47.

Dorrance, S., (1966), "Inflation and Growth: The Statistical Evidence", IMF Staff Papers, Vol. 13, no. 1, pp. 82–102.

Engle, R. F. and Granger, C.W.J., (1987), "Co-integration and Error Correction: Representation, Estimation and Testing". Econometrica, Vol. 55, pp. 251-276.

Engle, R.F. and Yoo, B.S., (1991), "Cointegrated economic time series: an overview with new results", in R.F. Engle and C.W.J. Granger, eds., Long-Run Economic Relationships, Oxford: Oxford University Press, pp.237-266.

Erbaykal, E. and Okuyan, H.A., (2008), "Does Inflation Depress Economic Growth? Evidence from Turkey". International Research Journal of Finance and Economics, Issue 17, no. 14502887.

Faria, J. R. and Carneiro, F.G., (2001), "Does High Inflation Affect Growth in the Long and Short-run?", Journal of Applied Economics, Vol. IV, No. 1, pp. 89-105.

Fisher, Stanley, (1993), "The Role of Macroeconomic Factors in Growth", Journal of Monetary Economics, Vol. 32 (December 1993), pp. 485-512. Granger, C.W.J. ,(1986), "Developments in the study of co-integrated economic variables", Oxford Bulletin of Economics and Statistics, vol. 48, pp. 213-228.

Fischer, S., Modigliani, F. (1978), Towards and understanding of the real effects and costs of Inflation. Weltwirtschaftliches Archiv, 114, 810-833

Frimpong, J.M., Oteng-Abayie, E.F. (2010), When is inflation harmful? Estimating the threshold effect for Ghana. American Journal of Economics and Business Administration, 2(3), 232-239.

Green, W.H, (2007), "Econometric Analysis," Sixth Edition, United States of America: Prentice Hall International.

Gregorio, J. (1996), Inflation, Growth and Central Banks: Theory and Evidence. Santiago Chile: Ministry of Finance Paper.

Guerrero, F. (2006), Does inflation cause poor long-term growth performance? Japan and World Economy, 18, 72-80.

Jarque, C.M., Bera, A.K. (1980), Efficient tests for normality, homoscedasticity and serial independence of regression residuals. Economics Letters, 6, 255-259.

Johansen, H.G., Harry, G. (1967), Is Inflation a Retarding Factor in Economic Growth? In Fiscal and Monetary Problems in Developing States, Proceedings of the Third Rehoboth Conference. p121-130.

Johansen, S. (1988), Statistical analysis of co-integration vectors. Journal of Economic Dynamics and Control, 12, 231-254. Johansen, S. (1991), Estimation and hypothesis testing of co-integration vectors in gaussian vector autoregressive models. Econometrica, 59, 1551-1580.

Johansen, S. (2006), Cointegration: A survey. In: Mills, T.C., Patterson, K., editors. Palgrave Handbook of Econometrics: Volume 1, Econometric Theory. Vol. 16. New York, NY: Palgrave Macmillan. p17-34.

Johansen, S., (1988), "Statistical analysis of cointegration vectors", Journal of Economic Dynamics and Control, vol. 12, pp. 231-254.

Johansen, S. and Juselius, K., (1990), "Maximum likelihood estimation and inference on cointegration-with the application to the demand for money", Oxford Bulletin of Economics and Statistics, vol. 52, pp. 169-210.

Johnson, Harry G., (1967), "Is Inflation a Retarding Factor in Economic Growth?", In Fiscal and Monetary Problems in Developing States, David Krivine, ed. Frederick A. Praeger Pub., pp. 121–37.

Kasidi, F., Mwakanemela, K. (2013), Impact of inflation on economic growth: A case study of Tanzania. Asian Journal of Empirical Research, 3(4), 363-380.

Khan, M.S. and Senhadji, S.A., (2001), "Threshold Effects in the Relationship between Inflation and Growth". IMF Staff Papers, Vol. 48, No. 1., pp 1-21.

Kwiatkowski, D., Phillips, P., Schmidt, P., Shin, P. (1992), Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54, 159-178.

Lucas, R., (1973),"Some International evidence on Output-Inflation Tradeoffs", American Economic Review, v.63, pp. 326-334.

Lupu, D.V. (2012), The Correlation between inflation and economic growth in Romania. Lucrari Stiinifice 5, 359-363

MacKinnon, J., (1991), "Critical values for cointegration tests", in R.F. Engel and C.W.J. Granger, eds., Long Run Economic Relationships: Readings in Cointegration, Oxford: Oxford University Press.

Mahmud, W. (1997), Growth or Stagnation? A Review of Bangladesh's Development 1996, Macroeconomic Update. Dhaka: Centre for Policy Dialogue, University Press Limited.

Malla, S. (1997), Inflation and economic growth: Evidence from a growth equation. Mimeo. Honolulu: Department of Economics, University of Hawaii at Monoa.

Mallik, G. and Chowdhury A., (2001), "Inflation and Economic Growth: Evidence from South Asian Countries", Asian Pacific Development Journal, Vol.8, No.1., pp 123-135.

Moses, Abramovitz, (1956), "Resource and Output Trends in the United States Since 1870", National Bureau of Economic Research, pp.1-23.

Michael, Y. (2008), The relationship between inflation and unemployment in Ethiopia'. M.A. Dissertation. Sudan: Department of Economics, Addis Ababa University.

Mubarik, Y. A., (2005), "Inflation and Growth: An Estimate of the Threshold Level of Inflation in Pakistan", State Bank of Pakistan – Research Bulletin, Vol.1, No. 1-2, pp. 35-44.

Munir Q. and Mansur K., (2009), "Non-Linearity between Inflation Rate and GDP Growth in Malaysia", Economics Bulletin, Vol. 29 no.3 pp. 1555-1569.

Mundell, R., (1963), "Inflation and Real Interest", the Journal of Political Economy, Vol. 71, No. 3, pp.280-283.

 Newey, W.K. and West, K.D., (1987), "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix", Econometrica, vol. 55, pp 703-8.

Pahlavani, M., Ezzati, P. (2011), The relationship between inflation and growth: Estimation of the threshold point for Iran. International Journal of Entrepreneurship and Management Research, 1(1), 47-61

Patterson, K. (2002), An Introduction to Applied Econometrics: A Time Series Approach. New York: Palgrave.

Paul, S., Kearney, C. and Chowdhury, K., (1997), "Inflation and economic growth: a multicountry empirical analysis", Applied Economics, vol. 29, pp. 1387-1301.

Pesaran, M. H., Shin, Y., Smith, R.J., (2001), "Bounds Testing Approaches to the Analysis of Level Relationships", Journal of Applied Econometrics, 16, pp. 289-326.

Phillips, P. C. B. and Perron, P., (1988), "Testing for a Unit Root in Time Series Regression", Biometrika, Vol. 32, pp. 301-318.

Pypko, S., (2009), "Inflation and Economic Growth: The Non-Linear Relationship. Evidence form CIS Countries", Kyiv School of Economics.

Ramsey, J.B. (1969), Test for specification error in classical linear least square regression analysis. Journal of the Royal Statistical Society, 31(2), 350-371.

Raza, J., Naqvi, M.A. (2013), Economic growth and inflation: A time series analysis of Pakistan. International Journal of Innovative Research and Development, 2(6), 689-702.

Rotemberg, J. (1982), Monopolistic price adjustment and aggregate output. Review of Econonzic Studies, 49, 517-531. Rotemberg, J. (1983), Aggregate consequences of fixed costs of price adjustment. American Economic Review, 73(3), 433-436

Sarel, Michael, (1996), "Nonlinear Effects of Inflation on Economic Growth" IMF Staff Paper; Vol. 43, Issue 1, pp.199-216.

Sargan, J. D., (1984), "Wages and Prices in the United Kingdom: A Study in Economic Methodology", Originally published in 1964 and reproduced. In K. F. Wallis and D. F. Hendry, eds., Quantative Economics and Econometric Analysis, Oxford: Basil Blakewell.

Sidrauski M., (1967), "Rational Choice and Patterns of Growth in a Monetary Economy", American Economic Review Papers and Proceedings, pp.534-544.

Solow, R. M., (1956), "A Contribution to the Theory of Economic Growth", Quarterly Journal of Economics (The MIT Press) 70, pp.65–94.

Solow, R. M., (1957), "Technical Change and the Aggregate Production Function", Review of Economics and Statistics (The MIT Press) 39, pp.312–320

Stockman, A. C., (1981), "Anticipated Inflation and the Capital Stock in a Cash-In-Advance Economy", Journal of Monetary Economics, 8 (1981), pp. 387-393.

Swan, T. W., (1956), "Economic Growth and Capital Accumulation", Economic Record (John Wiley & Sons) 32, pp.34–361.

Sweidan, O.D. (2004) Does inflation harm economic growth in Jordan? An econometric analysis for the period 1970-2000. International Journal of Applied Econometrics and Quantitative Studies, 1-2, 41-66.

Tobin, J., (1965), "Money and Economic Growth", Econometrica, Vol. 33, No.4, pp. 671-684.

Umi, O.R., Izuchukwu. A. (2016), Modeling the long run relationship between inflation and economic growth using the Engel and Granger approach (Evidence from Nigeria: 1985 to 2013). IOSR Journal of Humanities and Social Science, 21(4), 84-90.

Utkulu, U. (1997) How to estimate long-run relationships in economics: An overview of recent approaches. DEÜ IIBF Dergisi, 12(2), 39-48.

Valdovinoz, C.G.F. (2003), Inflation and economic growth in the long run. Economic Letters, 80, 167-173.

Wai, U. Tun, (1959), "The Relation Between Inflation and Economic Development: A Statistical Inductive Study", IMF Staff Papers, Vol. 7, no. 2, pp. 302–17.

White, H. (1980), A heteroscedasticity consistent variance matrix estimator and a direct test of heteroscedasticity. Econometrica, 48, 817-818.

Xiao, J., (2009), "The Relationship between Inflation and Economic Growth of China: Empirical Study from 1978 to 2007", Master's Thesis, Lund University.

"International Economy", (Winter 2003), The Magazine of International Economic Policy.

Yap, J.T. (1996), Inflation and Economic Growth in the Philippines. PIDS. Discussion Papers Series. No. 96-11.

Fraud and Misappropriation of Cryptocurrency Assets

Norazida Mohamed
Syakir Che Saruji
Akhbar Satar
Morrison Handley Schachler
Nasir Sultan

Abstract

The research uses the framework of the fraud diamond to analyse four cases of misappropriation of cryptocurrency assets between 2010 and 2023. The fraud diamond has four angles: pressure, opportunity, rationalization and capability. The fact that the existence of cryptocurrency assets is entirely based on electronic records is in theory an obstacle to the undetected misappropriation of assets and the laundering of stolen assets. However, this only reduces but does not eliminate opportunities for misappropriation and has no effect on pressures, rationalizations and capability. The reliance on electronic recording systems as part of a system of control and accountability is not sufficient in itself to prevent asset misappropriation. Factors affecting capability are highly significant in the prevention of cryptocurrency thefts and are strongly related to the ability of cryptocurrency thieves to recruit willing conspirators and accessories to help with the theft and laundering of the assets. Capability and pressure can also arise from the ownership or management of other businesses by the managers of cryptocurrency exchanges, giving rise to an inherent risk of fraudulent behaviour. Because frauds may be committed by those who are responsible for the design and implementation of control systems, it is especially important that regulators and auditors take cognizance of these inherent risks in conducting their work.

Keywords: Fraud, Fraud Diamond, Asset Misappropriation, Control, Cryptocurrency

Dr Norazida Mohamed is Senior Director of the Corporate Communications Department at Universiti Teknologi MARA, Malaysia.

Akhbar Satar is a member of academic staff of the Institute of Crime and Criminology at Help University, Malaysia.

Akhbar Satar is a Director of the Institute of Crime and Criminology at Help University, Malaysia.

Morrison Handley-Schachler is a retired lecturer in Accounting, Auditing and Financial Crime and formerly a member of academic staff at Edinburgh Napier University and Teesside University, United Kingdom.

Nasir Sultan is an Associate Professor at Department of Management and Administrative Sciences, University of Gujrat, Pakistan

Author contact details: Dr Norazida Mohamed, Accounting, Research Institute, Universiti Teknologi MARA, Cawangan Selangor, Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor, Malaysia. Email: Azida767@uitm.edu.my

1. Introduction

A wide variety of assets is open to misappropriation, including inventories (Omar, Nawawi and Salin 2016, Setiawan, Tarjo and Haryadi 2022), money received from customers (Kennedy 2018, Setiawan, Tarjo and Haryadi 2022) and cash in the form of notes and coins. The risk of asset misappropriation, however, does not solely relate to the risk of theft of employers' assets by employees. There is also a substantial risk of theft of investors' assets by senior employees in financial and investment institutions, especially where those employees have personal authority over two or more institutions, giving rise to opportunities for money-laundering an example being the fraud committed by Brown, using and Fidentia Asset Management and Living Hands Umbrella Trust as instrumental institutions, against Mineworkers' Provident Fund in South Africa (Marumoagae 2021) with loss of about 1.2billion Rand (c.US$60 million).

A recent development in asset creation has been the phenomenon of cryptocurrencies, which are private electronic currencies, such as Bitcoin and Ethereum, the existence of which is entirely dependent upon the recording of the creation and movement of currency units, thus potentially creating a complete record of the history of ownership of the assets. Nevertheless, the theft of cryptocurrency assets has not only occurred but been carried out without the identification of the initial perpetrators.

Thus, the research aims to assess the possible factors that might lead to asset misappropriation in the case of cryptocurrency assets. This research examines four cases of cryptocurrency misappropriation from the perspective of the fraud diamond, as developed by Wolfe and Hermanson (2004), which explores the need for pressure, opportunity, rationalization and capability for an individual to commit a fraud.

2. Literature Review

This study employs the Fraud Diamond Theory (Wolfe and Hermanson 2004). The Fraud Diamond (Figure 1) posits that an individual is influenced to commit an acquisitive financial crime by four factors: (1) personal **pressure**, which may result from personal domestic or business financial shortfalls as a result of a low income or high expenditure; (2) the **opportunity** to commit fraud; (3) the availability of a personal **rationalization** which makes the fraud appear necessary, inevitable or justified in the eyes of the potential perpetrator; and (4) the **capability** of the individual to commit the fraud, which is determined by intellectual, social and business factors, such as specialist education in fraud control systems, knowledge of the target victim as an individual or organization, occupation of a position of trust or power and access to a network of conspirators who can participate in a collusive fraud (Free 2015).

The fraud diamond may also have a relationship with the A-B-C model of financial crime described by Ramamoorti, Morrison and Koletar (2009). The A-B-C model presents the risks of fraud arising not only from a bad apple (who may be an individual with personal pressures or a mindset which rationalizes fraud) but also from a bad bushel, where a whole organization has become corrupt, as a result of corporate pressures or a corporate culture which encourages and rewards wrongdoing, which not only creates pressures and rationalization but also enhances the capability for fraud by presenting a wide choice of potential conspirators. The bad bushel is also likely to find ways of overriding or designing away control systems, thereby creating greater opportunities. However in the case of a whole industry which has become corrupted there will be a bad crop, in which it may become necessary for organizations to become bad bushels simply to survive. The bad bushel not only carries strong rationalizations for fraud but also presents numerous potential conspirators with a wide variety of skills and social and business contacts, thus greatly enhancing any individual's capability.

The emphasis in the literature relating to audit and control on reducing opportunity has several valid reasons behind it, despite the importance of capability, pressure and rationalization. Firstly, Kennedy (2018) and Setiawan, Tarjo and Haryadi (2022) provided evidence that the mere presence of an opportunity can be enough for a fraud to occur. Secondly, inquiring into pressures affecting an individual may be viewed as an unfair intrusion into the private lives of individuals in precarious circumstances, while inquiring into rationalizations requires a knowledge of the hearts of individuals which is simply not available to any other person. Finally the removal of individuals with the capability to commit serious frauds also involves the removal of talented individuals who have the capability to do useful work for the company. However, as was shown in the case of Jérôme Kerviel at Société Générale, capability relates not only to the individuals intellect and specialist education but also to his or her history with the potential victim organization. It may also relate to the availability of a network of conspirators (Free and Murphy 2013, Dai and Handley-Schachler 2015). However, preventing any contact with potential conspirators can also have a negative effect on business organizations, which rely on internal and external networks of labour in order to function.

3. Issues in the prevention and investigation of cryptocurrency fraud

In a fully electronic accounting and recording system, the opportunity to continue a fraud for a long period of time out to be substantially curtailed. Because electronic currencies rely on the pervasiveness of such recording systems, the opportunity angle of the fraud diamond ought, theoretically, to become far more acute, reducing the propensity to commit long-term fraud through a lack of long-term opportunities. Although this does not entirely prevent potentially high-value frauds with a shorter lifespan, the threat of easy detection, potentially early enough in the process to prevent the effective laundering of the proceeds of the fraud, might be expected to reduce the prevalence of fraud through the straightforward transfer of funds, making cryptocurrencies as an asset class secure against misappropriation. Where the ownership and value of a monetary token is entirely dependent on a series of electronic records showing the creation and all transfers of the token in question, fraudulent transfers of tokens without the consent of the current owners ought in theory to be readily traceable to the agent responsible for making the fraudulent transfer. Likewise the fraudulent dilution of the supply of tokens ought in theory to be readily traceable to the agents responsible for the creation of surplus tokens. The area of the fraud diamond is therefore reduced by narrowing the opportunity angle by reducing the opportunity for long-term asset appropriation schemes.

In particular, Bitcoin's blockchain system, whereby there is one global bitcoin ledger recording all transactions in sequence and creating a series of blocks reporting all previous Bitcoin balance sheets (Nakamoto 2008, Simply Explained 2017, Tyma et al. 2022), is designed to ensure that all transactions are traceable, with users also requiring private keys to create transactions (Wilusz and Wójtovicz 2022). From an accountability perspective, this might be held to improve the completeness and reliability of recording, although it does not guarantee that the assets recorded have any specific exchange value or that the information is relevant to users' needs. It also does not guarantee that private keys cannot be misused by hackers, although it should guarantee that the destination of any funds moved by misuse of private keys can be traced through the system.

However, the existence of a recording system does not guarantee that all transactions are wholly transparent. Many actors in the cryptocurrency market seek to remain anonymous from each other and from regulators (Sotiropoulou, .A., & Guégan, .D. 2017) and some of these actors may already be using cryptocurrencies for criminal purposes. This may reduce the practical traceability of the initial beneficial owners of cryptocurrency in the immediate aftermath of a theft, as well as providing a strong disincentive for victims who have acquired the assets illegally themselves to report it and a disincentive for managers of exchanges which lack anti-money-laundering controls to investigate.

4. Research Methodology

This research examines four recent cases of cryptocurrency fraud in order to examine the roles of pressure, opportunity, rationalization and capability in causing the frauds to occur. All four cases involve the misappropriation of cryptocurrency as an acquisitive offence. The research particularly focuses on the reasons why narrowing the angle of opportunity through the presence of complete electronic records did not prevent the frauds from occurring.

5. Case Studies

Case 1. Mt.Gox Bitcoin Exchange

The collapse of the Mt.Gox Bitcoin exchange in 2014 (Cekerevac et al. 2015, Lawrence & Mudge 2019,)
The Mt.Gox exchange, based in Tokyo (McMillan 2014), was formed in 2010 by the conversion of a collectible card exchange service founded in 2007, which explains the name Mt.Gox, from Magic The Gathering Online Exchange. The chief executive officer from 2010 onwards and majority shareholder, Mark Karpelès, had previously worked at Linux Cyberjoueurs as a software developer and network administrator. His background was in information technology and not in financial services.

In 2011, a hacker succeeded in diverting about 2,000 bitcoins (Lawrence & Mudge 2019, Cacioppoli 2022), then worth about US$8,500. However, the Mt.Gox exchange continued to expand operations, at one time conducting about 70 of global bitcoin trades (Cacioppoli 2022). In February, 2014, a further problem emerged in the form of a deliberate denial of service attack involving large volumes of electronic requests for the recording of malformed transactions, that is, fictitious transactions which did not appear in the Bitcoin ledger (Goodin 2014). This attack was not unique to Mt.Gox and did not permanently falsify records but it did slow down the exchange's operations and force it to suspend services.

However, later in the same month, Mt.Gox permanently ceased operations and sought protection from its creditors under Japanese corporate bankruptcy laws (McMillan 2014, (Sotiropoulou, .A., & Guégan, .D. 2017), following the loss of 850,000 Bitcoins, worth US$460 at the time, as a result of fraudulent diversion of Bitcoins by computer hacking – the exact type of event which the blockchain system was designed to ensure could be traced, along with the stolen Bitcoins. An increase in the value of the remaining Bitcoins was subsequently reported to be sufficient to meet legal obligations to creditors (Sarkar 2022), this subsequent development does not alter the fact that the asset misappropriation proved possible. Karpelès was subsequently convicted of false accounting in relation to Mt.Gox's own assets but he was acquitted of charges of embezzlement and criminal breach of trust (Pham 2019), which, from a fraud prevention and detection point of view, means that the details of the entries which led to the loss of the 850,000 bitcoins were never discovered. This implies that the availability of a technologically fool-proof recording system does not result in the detectability of fraudulent transactions within the system.

Mt.Gox Bitcoin Exchange and the Fraud Diamond

Because the perpetrators remain unknown the details of the **pressures** and **rationalizations** cannot be determined. However, the case demonstrates that without proper application of the blockchain system in an accountability relationship, opportunities can arise for cryptocurrency misappropriations. This is because reliable accounting records are not sufficient in themselves to prevent fraud. Fraud prevention also requires the identification of the creators and beneficial owners of cryptocurrency wallets, the application of protocols by both users and system administrators to prevent the misuse of user keys and the presence of accountability structure in which system administrators are answerable to the directors of the exchange and both directors and system administrators are answerable to traders on the exchange. It also requires all traders to be sufficiently identifiable to those whose assets they are trading, to enable investors to identify unauthorized transactions. The lack of adequate accountability structures appears to have played a key part in creating an **opportunity** for the fraud to occur, despite the existence of reliable information systems. However, a key angle in the fraud diamond here is that of **capability.** Too much reliance was placed on executives with a purely technological background and perpetrators with an understanding of the flaws in accountability systems, in particular systems to identify all participants, were this enabled to gain an advantage over customers of an enterprise which lacked capabilities in overall control structures and systems auditing.

Case 2. Coincheck

Coincheck, another Japanese company, was founded in 2012 and was acquired by the Monex Group in 2018 (Crunchbase 2023). The exchange enables trading in cryptocurrencies including XEM. On January 26[th.], 2018, hackers gained unauthorized permissions to make transactions draining US$34 million worth of XEM and other cryptocurrency, including some investors' funds, from Coincheck's own wallet. This fraud was detected much more quickly than the Mt.Gox fraud (Arsene 2018, Au 2018) and investigated with assistance from the NEM Foundation which created XEM (Au 2018) and Coincheck were able to refund investors. Subsequently, charges were brought against at least 30 people in relation to handling the stolen cryptocurrency (Sinclair 2021). However, despite the requirement for electronic recording of the theft in order to make it possible, the perpetrators of the original crime have never definitely been identified.

Coincheck and the Fraud Diamond

Once again, the original perpetrators remain unknown, making their **pressures** and **rationalizations** impossible to determine. In this case, the **opportunity** arose because of a weakness in control systems which allowed unauthorized access to the system to make transactions on Coincheck's behalf, in other words, an old-fashioned computer hack, requiring the usual **capability** for this kind of attack. A key difference between the Coincheck and Mt.Gox cases, however, is that the time-window of opportunity was very small because internal control systems quickly detected the fraud. The pressures and rationalizations of the many people involved in laundering the stolen cryptocurrency will have varied. The mere existence of stolen assets held by somebody with a motive to circulate them to others as fast as possible created an opportunity for receiving the stolen assets. The sheer number of perpetrators at this secondary stage makes it unlikely that the pressures and rationalizations under which each individual operated could have been predicted, thereby making any system which relies on detecting or weakening pressures and rationalizations very unreliable. However, in another major contrast with the Mt.Gox case, the individuals involved in money laundering were rapidly brough to justice, demonstrating that the capability of the organization which was the victim and instrument of the fraud to trace money laundering transactions was a key factor in reducing the window of opportunity.

Case 3. Bitfinex

Bitfinex was founded as a cryptocurrency exchange in 2012 (Bitfinex 2022). In 2016, a series of 2,000 transactions were processed routing 119,754 Bitcoins, worth US$72 million at the time, held on the Bitfinex exchange into a single Bitcoin wallet. These transactions were created fraudulently by computer misuse (Chow 2022).

In February 2022, two individuals, technology entrepreneur Ilya "Dutch" Lichtenstein and freelance journalist Heather Morgan, were arrested and charged with laundering some of the bitcoins stolen by the hackers from investors in the Bitfinex exchange (United States Department of Justice 2022c). The case has yet to come to trial and plea bargaining negotiations are taking place (Tisdale 2022). The bitcoins were traced to a single wallet but it was not certain at the time of the arrest whether Lichtenstein and Morgan were involved in the original hack. Once again, a significant feature of the case is that the arrests were made on the basis of information about subsequent movement of the misappropriated assets and not on the basis of any successful action directly to trace the source of the original hack.

Bitfinex and the Fraud Diamond

Once again, the original perpetrators are not known, making their **pressures** and **rationalizations** impossible to determine. An extravagant but precarious lifestyle, however, and an oversold online persona (Caesar 2022) based on little in the way of experience or qualifications was likely to have contributed to pressures on the two individuals charged with money laundering to demonstrate the possession of personal wealth by whatever means. As with Coincheck, the **opportunity** arose from a failure to prevent an old-fashioned computer hack. However, in this case, the length of time between the original hack and the detection of money laundering points to an incomplete opportunity. Although the bitcoins were transferred to a wallet for use, the ability to bring them back into circulation was evidently limited at the time of the original fraud. The opportunity was limited by the prospect of monitoring of the wallet by Bitfinex and law enforcement. However, another key aspect is the evident lack of **capability** on the part of any of the perpetrators to complete the money laundering phase of the fraud. The bitcoins were not moved from the wallet quickly enough to exchange them for other assets which could not be easily identified, indicating that the perpetrators lacked a reliable plan or reliable methods for rapid disposal of the stolen assets. It is not possible to determine the extent to which Bitfinex would have been able to prevent laundering of the initial proceeds of the fraud if the perpetrators had possessed this capability. However, the systems in place did facilitate the identification of the stolen cryptocurrency, reducing the opportunity for successful money laundering.

Case 4. FTX Exchange

In 2022, FTX exchange in Bahamas founded and run by Sam Bankman-Fried, collapsed after embezzlement of investor funds, for which Bankman-Fried is presently being prosecuted. About US$10 billion in investors' funds disappeared with a general lack of book-keeping at the exchange. In this case, the perpetrators of the fraud were executive managers at the FTX exchange and at Alameda Research, a trading firm also founded by Bankman-Fried. At present, Bankman-Fried himself is awaiting trial on charges of wire fraud and money laundering (United States Department of Justice 2022a, Haqshanas 2023), while Caroline Ellison, former Chief Executive of Alameda Research, and Gary Wang, another FTX executive, have already pleaded guilty to related charges (Teh 2022, United States Department of Justice 2022c) and a further FTX executive, Nishad Singh has also been indicted (Haqshanas 2023). The fraud was committed against investors who traded on FTX, whose funds were embezzled. Prosecutors allege that:

> "Bankman-Fried and his co-conspirators perpetrated a scheme to defraud customers of FTX by misappropriating billions of dollars of those customers' funds. Bankman-Fried allegedly used billions of dollars of FTX customer funds for his personal use, to make investments and millions of dollars of political contributions to federal political candidates and committees, and to repay billions of dollars in loans owed by Alameda Research, a cryptocurrency hedge fund also founded by the Bankman-Fried. Bankman-Fried also allegedly defrauded lenders to Alameda Research and equity investors in FTX by concealing his misuse of customer deposits in financial information that was provided to them."

(United States Department of Justice 2022a)

The auditors of FTX's international operations, Prager Metis and the auditors of FTX US, Armanino, who audited financial statements for the years ending in 2020 and 2021, have both been named as defendants, alongside Bankman-Fried and others, in a class action lawsuit brought by Stephen Pierce, on behalf of himself and other investors, on November 23rd 2022 (Hoda Law Firm and Steven C. Vondran 2022). Armanino claimed to have performed the audit to the standard required for private limited companies in the USA but said that they had not audited all internal control systems. However, an interim manager at FTX stated that the financial reports were not reliable (Foley 2022).

It is of particular note that the auditors have been named as defendants in this case, highlighting the view that the fraud was preventable through normal control systems and detectable through standard auditing procedures.

FTX and the Fraud Diamond

The **pressure** in this case arose from troubles in another enterprise under common ownership and management with FTX and from other financial relationships. The **opportunity,** however appears to have arisen from the position of the perpetrators in the organization and from regulatory and accountability failures. This case differs from the other three in that the perpetrators of the original fraud are known and they are known to have been executives involved in the management of the exchange and of other related enterprises and with a personal financial interest therein. The lack of separation of ownership and control does not appear to be the key issue here. Rather, an alleged lack of vigilance by those charged with auditing the enterprise is a possible explanation for the opportunity which arose. FTX was not the victim but the instrument of the fraud. The perpetrators were those who had responsibility for implementing the control systems which were required to prevent the fraud. The fraud has similarities with that conducted against investors by Bernie Madoff and others in the case of Madoff Investment Securities. In both cases, the fraud was committed by means of a conspiracy. In both cases the conspiracy was led or allegedly led by the Chief Executive of the company which was used as an instrument in the fraud. In both cases, the victims were investors who had entrusted funds to the perpetrators as managers of the enterprise. In both cases, serious audit failures occurred. In the case of Madoff Investment Securities, the auditor David Friehling was convicted as one of the conspirators, while in the case of FTX the financial statements on which the auditors had given an unqualified opinion were subsequently declared to be unreliable. Audit failures are a key factor in creating opportunities for fraud against investors, regardless of the asset class involved, which may be cash, cryptocurrency, equities or bonds. Where there is no separation between ownership and control of either an exchange or a brokerage, investors run the risk that owners will elect auditors who cannot be relied on to report on management failings or outright fraud. The need for further audit by regulators or due diligence by those investors who are in a position to obtain sufficient information is therefore essential in reducing the risk of fraud against investors. In cases such as this, the **capability** required includes some technological skill and the ability to create an illusion of either reliability or unusual investment talents. However, the key element in the capability angle is not personal ability but the recruitment of conspirators to enable the fraud. The matter is complicated by the fact that an alleged conspirator was responsible for designing and overseeing the control system which should have prevented the theft. The fraud can therefore be seen as a regulatory and auditing failure, in which investors, who are customers of the exchange, are not protected from the dishonest operation of exchanges.

6. Conclusion

Asset misappropriation is a serious problem that has a significant impact on organizations' strategic and operational functions. In the case of cryptocurrency misappropriation, it can also have a serious negative effect on investors. The existence of complete recording systems has the potential to reduce the opportunity for cryptocurrency misappropriations. Unfortunately, recording systems do not of themselves constitute a complete system of control and accountability. There is also a requirement for transparency about the beneficial owners of cryptocurrency in cryptocurrency wallets and about the identities of the persons controlling those wallets. Neither of those conditions is guaranteed to exist.

In addition, there is a particular danger of fraud when those responsible for the design and maintenance of the internal controls in a cryptocurrency exchange are subject to pressure to commit embezzlement. The ability to design away or override key controls aimed at protecting investors' assets creates an opportunity, which has not always been blocked by competent regulatory or auditor action. In addition, the ability to recruit conspirators in related organizations continues to be a key part of the capability to commit fraud.

While the emphasis on control systems to reduce the opportunity for fraud is a suitable strategy for he prevention of asset misappropriation, there is a risk of placing excessive confidence in the ledger system which is merely a recording system. Without proper accountability and without transparency about the owners of currency and controllers of currency wallets this recording system does not form part of a viable system of controls.

In addition, regulators and auditors must take seriously the inherent risks resulting from both the pressures and the capabilities which can arise from the business interests of the owners and managers of exchanges and regulators must ensure that management are accountable to investors, that is, to customers whose assets they hold, and not only to owners, who may be the same people as the management.

References

Arsene, L. (2018), "Coincheck hack ghosts $534 million worth of cryptocurrency," *Bitdefender* https://www.bitdefender.com/blog/hotforsecurity/coincheck-hack-ghosts-534-million-worth-of-cryptocurrency/

Au, K. (2018), "Tracing back stolen cryptocurrency (XEM) from Japan's Coincheck," *Forbes* January 29th., https://www.forbes.com/sites/outofasia/2018/01/29/tracing-back-stolen-cryptocurrency-xem-from-japans-coincheck/?sh=9934a4d277eb

Bitfinex (2022), *We are Bitfinex: Your Assets, Your Choices, Our Technology,* https://www.bitfinex.com/about

Cacioppoli, V. (2022), "Story of the Mt. Gox exchange," August 28th., *Cryptonomist,* https://en.cryptonomist.ch/2022/08/28/story-mt-gox-exchange/

Caesar, E. (2022), "How a young couple failed to launder billions of dollars in stolen Bitcoin," *New Yorker* February 14th., https://www.newyorker.com/business/currency/how-a-young-couple-failed-to-launder-billions-of-dollars-in-stolen-bitcoin

Cekerevac, Z., Dvorak, Z., Prigoda, L., & Cekerevak, P. (2015), "Risks of bitcoin virtual currency," *Communications – Scientific Letters of the University of Zilina* 2015(1):93-98.

Chow, A.R. (2022), "Inside the chess match that led the feds to $3.6 billion in stolen bitcoin," *Time* February 10th., https://time.com/6146749/cryptocurrency-laundering-bitfinex-hack/

Dai, Y., & Handley-Schachler, M. (2015), "A fundamental weakness in auditing: The need for a conspiracy theory," *Procedia Economics and Finance* 28:1-6.

Foley, S. (2022), "FTX US auditor Armanino defends work for failed crypto exchange," *Financial Times* December 23rd., https://www.ft.com/content/42087255-92ad-45b7-b5ad-3b8457e0c1f8

Free, C. (2015), "Looking through the fraud triangle: A review and call for new directions," *Meditari Accountancy Research* 23(2):175-196.

Free, C., & Murphy, P. (2015), "The ties that bind: The decision to co-offend in fraud," *Contemporary Accounting Research* 32(1):18-54.

Gooding, D. (2014), "Bitcoin exchanges buckle under the strain of phantom transactions," A*rs Technica* February 11th., https://arstechnica.com/information-technology/2014/02/bitcoin-exchanges-buckle-under-strain-of-phantom-transactions/

Haqshanas, R. (2023), "FTX scandal deepens: Sam Bankman-Fried's right-hand man Nishad Singh to plead guilty to fraud," *Cryptonews* February 18th., https://cryptonews.com/news/ftx-scandal-deepens-sam-bankman-frieds-right-hand-man-nishad-singh-to-plead-guilty-to-fraud.htm

Hoda Law Firm and Steven C. Vondran (2022), *Class Action Lawsuit, United States District Court for the Northern District of California, San Francisco & Oakland Division, Pierce v Bankman-Fried,* November 23rd., https://www.courthousenews.com/wp-content/uploads/2022/11/FTX-class-action.pdf

Kennedy, J.P. (2018), "Asset misappropriation in small businesses," *Journal of Financial Crime* 25(2):369-383.

Lawrence, C.J., & Mudge, S.L. (2019), "Movement to market, currency to property: The rise and fall of bitcoin as an anti-state movement, 2009–2014," *Socio-Economic Review* 17(1):109-134.

Marumoagae, M.C. (2021), "The need to adopt preventative measures to combat the misappropriation of retirement fund assets," *Potchefstroom Electronic Law Journal* 24:1-35.

McMillan, R. (2014), "The inside story of Mt. Gox, bitcoin's $460 billion disaster," *Wired* March 3rd., https://www.wired.com/2014/03/bitcoin-exchange/

Nakamoto, S. (2008), *Bitcoin: A Peer-to-Peer Electronic Cash System,* https://www.ussc.gov/sites/default/files/pdf/training/annual-national-training-seminar/2018/Emerging_Tech_Bitcoin_Crypto.pdf

Omar, M., Nawawi, A. and Salin, A.S.A.P. (2016), "The causes, impact and prevention of employee fraud: A case study of an automotive company," *Journal of Financial Crime* 23(4):1,012-1,027.

Pham, S. (2019), "Former Mt. Gox chief Mark Karpeles acquitted of most charges in major bitcoin case," *Cable News Network* March 14th., https://edition.cnn.com/2019/03/14/tech/mark-karpeles-mt-gox/index.html

Ramamoorti, S., Morrison, D., and Koletar, J.W. (2009), "Bringing Freud to fraud: Understanding the state-of-mind of the C-level suite/white collar offender through A-B-C analysis," *University of Dayton Accounting Faculty Publications* no.71, https://ecommons.udayton.edu/cgi/viewcontent.cgi?article=1072&context=acc_fac_pub

Sarkar, A. (2022), "Update: Mt. Gox 6,800 BTC not linked with ex-CEO's plans to redistribute $6b," *CoinTelegraph* April 2nd., https://cointelegraph.com/news/mt-gox-wallet-transfers-6-800-btc-as-ex-ceo-plans-to-redistribute-6b

Setiawan, N., Tarjo and Haryadi, B. (2022), "Asset misappropriation employee fraud: A case study on an automotive company," *Jurnal Ilmiah Akutansi dan Bisnis* 17(2), pp.214-233.

Simply Explained (2017), "How does a blockchain work – Simply explained," https://www.youtube.com/watch?v=SSo_EIwHSd4

Sinclair (2021), "30 charged in Japan with trading $96m of crypto stolen in Coincheck hack," *CoinDesk* January 22nd., https://www.coindesk.com/policy/2021/01/22/30-charged-in-japan-with-trading-96m-of-crypto-stolen-in-coincheck-hack/

Sotiropoulou, .A., & Guégan, .D. (2017), "Bitcoin and the challenges for financial regulation," *Capital Markets Law Journal* 12(4):466-479.

Teh, C. (2022), "Caroline Ellison, the former CEO of Alameda, pleads guilty to charges that carry up to 110 years in prison following FTX collapse," *Business Insider* December 22nd., https://www.businessinsider.com/caroline-ellison-faces-110-years-in-prison-after-guilty-plea-2022-12?r=US&IR=T

Tisdale, J. (2022), " 'ABC News' investigates the bitcoin Bonnie and Clyde in 'Truth and lies: The crocodile of Wall Street'," September 15th., *Distractify* https://www.distractify.com/p/heather-morgan-ilya-lichtenstein-bitcoin-now

Tyma, B., Dhillon, R., Sivabalan, P., & Wieder, B. (2022), Understanding accountability in blockchain systems. Accounting, Auditing & Accountability Journal, 35(7):1,625-1,655.

United States Department of Justice (2022a), "FTX Founder Indicted for Fraud, Money Laundering, and Campaign Finance Offences," *Justice News* December 13th., https://www.justice.gov/opa/pr/ftx-founder-indicted-fraud-money-laundering-and-campaign-finance-offenses#:~:text=Bankman-Fried%20is%20charged%20with,of%2020%20years%20in%20prison.

United States Department of Justice (2022b), *Re United States vs. Caroline Ellison* December 18th., https://www.documentcloud.org/documents/23495436-crypto-cooperator-ftx-alamedas-caroline-ellisons-plea-agreement-inner-city-press-on-the-case

United States Department of Justice (2022c), "Two arrested for alleged conspiracy to launder $4.5 billion in stolen cryptocurrency," *Justice News* February 8th., https://www.justice.gov/opa/pr/two-arrested-alleged-conspiracy-launder-45-billion-stolen-cryptocurrency

Wilusz, D., & Wójtowicz, A. (2022), Secure protocols for smart contract based insurance services. Expert Systems, 39(9), https://doi.org/10.1111/exsy.1290

Wolfe, D.T., and Hermanson, D.R. (2004), "The fraud diamond: Considering the four elements of fraud," *CPA Journal* 74(12):38-42.

Figure 1. The Fraud Diamond
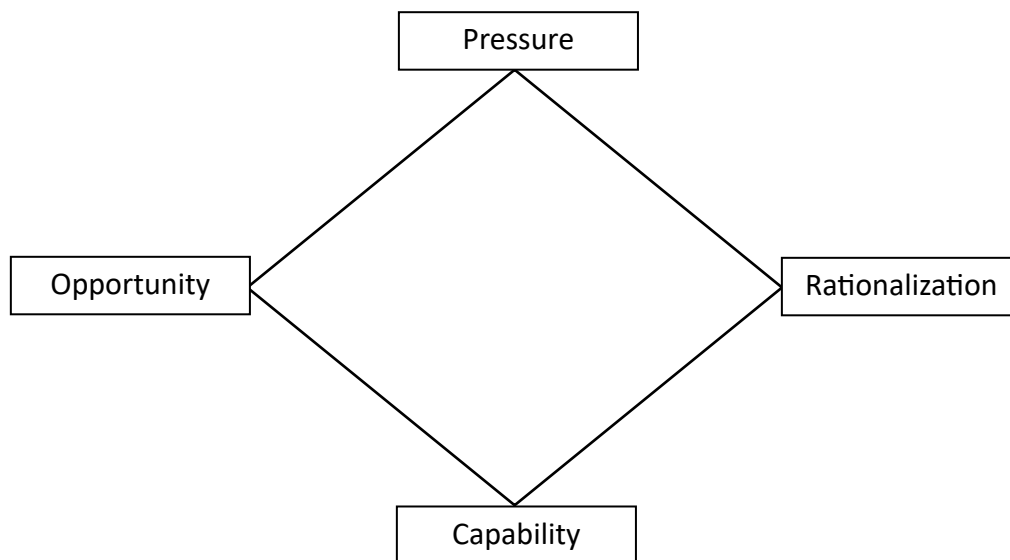
Wolfe and Hermanson (2004)

Food Insecurity, Food Security, Welfare, and Sustainability in Canada
A Quantifying Approach - *From Micro to Macro*

Ghana Gomaa A. Mohamed, PhD., PDFs
Dean of Students; Global Forward Academy
President: ECO-ENA: Economics & ECO-Engineering Associate, Inc.

Abstract: This manuscript provides a mathematical approach to measuring food security, linking it mathematically to the concept of social welfare over time to figure out the impact of food security on the transitional dynamism of social welfare. The utilized mathematical approach in this manuscript is essential as a foundation for further research on food insecurity/ security, consumer behaviour, and social welfare over time.

Keywords: Food Insecurity, Food Security, Consumer Surplus, Consumer Confidence, Social Welfare, Sustainability, Survey Analysis, Intervention Analysis, Time Series Data, Canada

JEL. C, Q

Introduction.

This manuscript depends on the definition of Health Canada of the concepts of food insecurity and food security. In addition to the definition of the FAO of food security. On the other side, it depends on Weitzman's definition of social welfare. It also depends on the Canadian Household Food Security Survey Modules (HFSSM) to measure food insecurity.

This manuscript provides a mathematical approach to measuring food security, linking it mathematically to the concept of social welfare over time to figure out the impact of food security on the transitional dynamism of social welfare. The utilized mathematical approach in this manuscript is essential as a foundation for further research on food insecurity/ security, consumer behaviour, and social welfare over time.

This manuscript is structured as follows. Section II, after the introduction, provides the implicit function of food insecurity. Section III explains the explanatory variables of the food security function. Section III provides a mathematical calculation to derive the data trend of food security. Section IV presents the term social welfare and its measure. Section V introduces the intervention time series model to determine food security's impact on social welfare over time. Section VI provides the implications and the conclusion of the manuscript.

II. Definitions and The Food Security Function.

According to Health Canada, "food insecurity is the inability to acquire or consume an adequate diet quality or sufficient quantity of food in socially acceptable ways, or the uncertainty the one will be able to do so.".
The 1996 World Food Summit provided a broad definition of food security., I.e., "Food Security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." (FAO, 1996).

The Food Policy Canada defines security as "All people in Canada can access a sufficient amount of safe, nutritious, and culturally diverse food." And added that "Canada's food system is resilient and innovative, sustains our environment and supports our economy." (AAFC).

The Household Food Security Survey Module (HFSSM) measures food insecurity. This tool has been included in Statistics Canada's Canadian Community Health Survey since 2004 and in the Canadian Income Survey (CIS) since 2019.)PROOF, 2022).   The appendix provides the questionnaire for this survey.

We can assume different factors affect food. According to this survey, four types of people can be identified: a more protective person against food insecurity, a vulnerable person to food insecurity, a secure food person, and a food insecure person. On the other hand, households not identified as food insecure are considered food safe. (PROOF, 2022).

The food insecurity function can be explained as follows.

Food Insecurity = f(financial factors, social & cultural factors, human behaviour, uncertain macro factors).

The financial factors are about the household's disposable income and food prices. In other words, the financial factors could be represented by the consumer surplus, which can be explained on the macro level in the following section of this manuscript. Assuming that the gross consumption can be derived as a function of disposable income. Wealth could be added as one of the financial factors as well.

The social and cultural factors are cultural diversity, family kinship, community cooperation, age, gender, education, isolation, and bleakness. The social and cultural factors can be measured via a survey to determine the number of populations that suffer from negative social and cultural integration. To simplify, it can be measured by the number of immigrants in Canada every year, assuming that; immigrants take time for social and cultural integration. The data trend is available in this case.

Human behaviour toward food assistance programs is about positive behaviour toward food assistance programs or negative behaviour toward food assistance programs. "A cognitive game approach can cognitively explain this behaviour." To neutralize, we can consider only positive behaviour toward social assistance. The consumer confidence index in Canada could measure this. The data trend is available in this case.

The uncertain macro-factors are about food supply chain blocks, crises, etc. This is considered a random term. To simplify, let's assume that the random term is a white noise disturbance term.

The above function can then be rewritten as follows.

FI = f(X1, X2, X3, e).

Where; *FI refers to food insecurity, X1* refers to the consumer surplus term, *X2* refers to the social/ cultural integration term, *X3* refers to the consumer confidence index, and e refers to the uncertainty.

III. How to measure the consumer surplus on the macro-level. From Micro to Macro.

The consumer surplus is measured by the difference between what they are willing to pay and what they are actually paying. From a macroeconomic perspective, we can take the CPI as a proxy of what the consumers are actually paying in the economy, while the entire area under the aggregate demand is what the consumers are willing to pay. In different words, the consumer surplus is theoretically feasible within the area located under the demand and above the price. (Mohamed & Javid (2014)).

If we consider on the macro level that the entire demand is the gross nominal private consumption, then; the consumer surplus on the macro level can be determined mathematically as follows:

The consumer surplus = ln (nominal gross consumption) - ln(CPI); this equals the real gross consumption. Therefore, the real gross consumption in the economy can be considered a proxy of the consumer surplus. (Mohamed & Javid (2014)). The trend data of the real gross consumption is available.
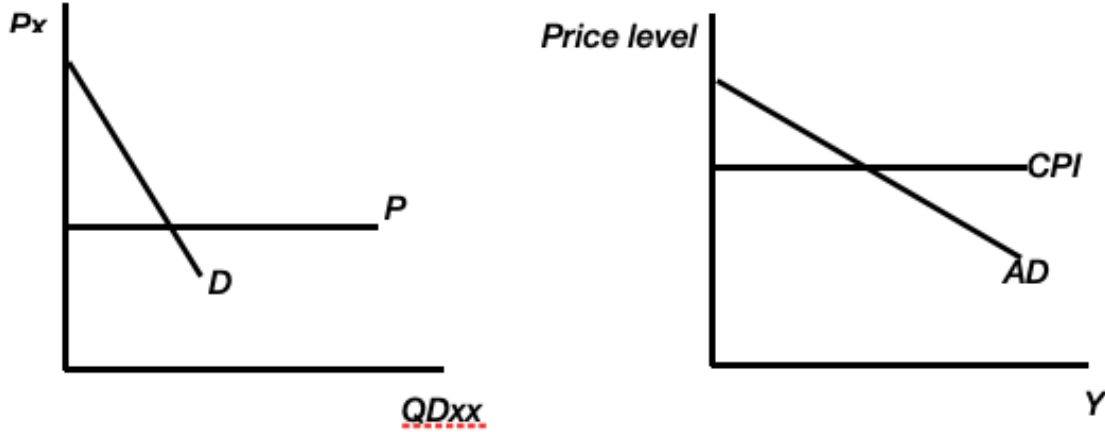
This entire section depends on the same author's analysis in her paper with Saima Javid (2014); however, here, we can consider the GDP of the natural resources, not the entire GDP of the economy. The trend data is available in Canada as well. For more explanations, Px refers to the price of a good X; *QDx* refers to the quantity demanded of a good X, P is the price of this good and D is the demand for this good. *Y* is the real GDP of the natural resources, the *CPI* is the consumer price index, and *AD* is the aggregate demand.

IV. How to estimate the trend data of food security.

In this section, we explain how to estimate the trend data of food security. We can do so in two steps;

Step 1 by using the results of the Household Food Security Survey Module (HFSSM) in Canada. We then estimate the explained model in the previous section. After selecting the best-fit model, we forecast it to figure out the data trend of food insecurity. - We can control all econometric problems here. The estimated food insecurity function over time is as follows:

$$FI_t = a + bX1_t + cX2_t + cX3_t + e_t.$$

Step 2: generating the data of the food insecurity from the previous model directly as follows:

Recall; *FI = f (X1, X2, X3)*, considering the macro uncertainty is zero. By taking the total differentiation of this function, thus.,

dFI = dX1. (∂FI/ ∂X1) + dX2.(∂FI/∂X2) + dX3.(∂FI/∂X3).
By minimizing food insecurity, the *FI*, as a policy, then.,
dFI = dX1. (∂FI/ ∂X1) + dX2.(∂FI/∂X2) + dX3.(∂FI/∂X3) = 0.

Where the $(\partial FI/\ \partial X1)$ is the sensitivity of the change of food insecurity to the change of the financial factors, the $(\partial FI/\partial X2)$ is the sensitivity of the change of food insecurity to the change of the social/ cultural factors, and the $(\partial FI/\partial X3)$ is the sensitivity of the change of the food insecurity to the change of the human behaviour variable.

Mathematically speaking, we link the coefficients *a*, *b*, and *d* mathematically to the partial differentiation terms. - We then can calculate the data trend of the food insecurity variable.

V. How to measure social welfare over time - Macro-sustainability.

According to t Weitzman (2001), "the difference in inter-temporal welfare between two points in time of the same economy can be exactly measured by the difference in real national income plus a consumer surplus term.".

Recalling Weitzman's statement and our macro-explanation of the consumer surplus term, then;

The intertemporal welfare between two points in time t & t-1 = (the real national income + the real gross consumption)t - (the real national income + the real gross consumption)t-1.

Now, we have a quantitative variable that reflects the welfare over time. (Mohamed & Javid (2014)).

This entire section depends on the same author's analysis in her paper with Saima Javid (2014); however, here, we can consider the GDP of the natural resources, not the entire GDP of the economy.

Accordingly, the trend data of social welfare over time can be easily derived from the relevant trend data in Canada.

VI. The impact of food security on social welfare over time - sustainability.

With two quantitative variables, i.e., food security and welfare, we can then figure out the transitional dynamic impact of food security on social welfare by utilizing an intervention time series model as follows:

$$Wt = a0 + A(L)\ W(t\text{-}1) + c0\ FSt + B(L) + \varepsilon t.$$

Where; the *W* refers to social welfare, *FS* refers to the food security which is the intervention variables, and a0 is the constant term. The *A(L)* and the *B(L)* are polynomials in the lag operator, and the εt is the disturbance term.

After doing all relevant data checks, we run the ARMA with the intervention variable up to ARMA (3,3) until selecting the best-fit model. By forecasting the model, we can figure out the transitional dynamism of the impact of food security on social welfare over time. (Mohamed & Irandoust (2023)).

VII. Conclusion and Implications.

This manuscript provided a quantitative approach to measuring the variable of food security, hence providing trend data to figure out the transitional impact of food security on social welfare over time. Yet, this manuscript should be extended to provide data analysis for Canada as the country case study taken in this manuscript.

References.

Deaton, B. J., & Scholz, A. (2022). Food security, food insecurity, and Canada's national food policy: Meaning, measures, and assessment. *Outlook on Agriculture*. 51(3), 303-312. https://doi.org/10.1177/00307270221113601

Mohamed, G.,G., & Saima J. (2014). The Impact of Foreign Direct Investment on Dynamic Net Social Welfare in Saudi Arabia - A quantifying macroeconomic approach- Time Series Analysis. *International Journal of Academic Research in Economics and Management Sciences*. 3(4), 1-8. DOI:10.6007/IJAREMS/v3-i4/1066

Mohamed, G. G. A., & Irandoust, M. . (2022). A Dynamic Analysis of Financial Interruption on a Small Open Economy: A Case Study on South Africa. *Asian Economic and Financial Review*, *12*(5), 317–328.

PROOF research work on food insecurity in Canada, University of Toronto.

Appendix

The International Conference of Economics & Agribusiness

The International Conference of Economics & Agribusiness

CONFERENCE E-PROCEEDING:
ISBN: 978-1-988081-13-7: LIBRARY AND ARCHIVES CANADA

Online Conference - Zoom meetings - English/ Spanish Presentations - September 10th & 11th, 2021.

SCIENTIFIC COMMITTEE AND CONFERENCE CHAIRS:

Amir Kia akia@uvu.edu		Thomas Henschel henschel@htw-berlin.de
Morrison Handley-Schachler M.Handley-Schachler@napier.ac.uk	Ghada G. Mohamed gmohamed@eco-ena.ca,	Daniel May dmay@harper-adams.ac.uk

Academic Collaboration: The School of Commercial Engineering, Austral University, Puerto Montt, Chile http://ingenieriacomercialpm.uach.cl/

Conference Reporting: https://www.eco-ena.ca/2021-research-week_1.html

PRESENTERS:

Presenters	Affiliation	Presentation
Andrés Álvarez **Mirta Barría Victoria** **Galleguillos**	Austral University of Chile. School of Commercial Engineering, Puerto Montt	"Assessing the effects of a change of aggregated demand on employment in companies according to their size: a study case in Chile.
Valentina Barrientos **Rocío Oñate** **Tamara Oyarzo**	Austral University of Chile. School of Commercial Engineering, Puerto Montt	"Exploring consumers' psychological effects on patterns of consumption of clothing items: a focus on young and adult people"
Pamela Theofanous	Harper Adams University, UK	"Examining spatial price linkages in major EU Olive oil Markets through a Systematic Map"
Patricio Pesce Quezada	Universidad Miguel de Cervantes, Chile	"An investigation of differential requirements to develop the appropriate skills across members of organizations"
Isabel Nuñez **Valeria Serpa**	Austral University of Chile. School of Commercial Engineering, Puerto Montt	"A Study of the Impact of Educational Levels on Innovation Development"
Valeria Vera **Daniela Villarroel**	Austral University of Chile. School of Commercial Engineering, Puerto Montt	Impact of Covid-19 on consumption patterns in Puerto Montt"
Paulina Bahamonde **Javiera Velásquez**	Austral University of Chile. School of Commercial Engineering, Puerto Montt	"A study of people's indebtedness in the Lagos Region of Chile before and during the period of health crisis COVID-19"
Ourania Tremma	Harper Adams University, UK	"The relationship between US corn, crude oil and Ethanol Prices"

Presenters	Affiliation	Presentation
Geraldine Carrasco **José Castillo** **Daniela Hernández**	Austral University of Chile. School of Commercial Engineering, Puerto Montt	"Imperfect competition in the Chilean wine market: a qualitative research"
Amir Kia	Utah Valley University	"Demand for Money in the United States: Stability and Forward-Looking Tests"
Morrison Handley-Schacher	Edinburgh Napier University	"Drivers of Drug-Related Financial Crime and Some Short-term Predictions"
Daniel May	Harper Adams University & Austral University Puerto Mont	"Explaining Lack of Agricultural Trade Liberalization: A Network Approach"
Ghada Mohamed	Forward Academy (Dean) & ECO-ENA (President)	"Food Waste/ Loss Reduction."

ABSTRACTS

The International Conference of
Economics and Agribusiness

Assessing the effects of a change of aggregated demand on employment in companies according to their size: a study case in Chile

Andrés Álvarez, Mirta Barria and Victoria Galleguillos

Abstract

In this research, taking Chile as a reference, the size of companies and their generation of employment are related to variables such as final demand, changes in consumption, economic growth and technological development. Based on the above, the impact of the variables first mentioned on job creation will be analyzed, specifically when they undergo a change. Given this, it will be observed how Chilean companies affect the generation of employment according to their business size (micro, small, medium and large companies), to achieve this a quantitative approach will be used, called input-product which allows obtaining an employment multiplier from matrix calculations of the Leontief demand model. The information that will be used corresponds to the year 2017 and is provided by the Internal Revenue Service (SII), INE (ISIC) and the Central Bank of Chile.

Keywords: Company size; aggregated demand; employment.

EXPLORING CONSUMERS' PSYCHOLOGICAL EFFECTS ON PATTERNS OF CONSUMPTION OF CLOTHING ITEMS: A FOUCS ON YOUNG AND ADULT PEOPLE

Valentina Barrientos, Rocío Oñate and Tamara Oyarzo

Abstract

This article aims to determine how psychological considerations influence consumer purchasing behavior of clothing items. In order to relativize these considerations, other non-psychological factors were also considered with the purpose of assessing the relevance of psychological factors. The methodology adopted in this investigation corresponds to a mixed method approach referred to as exploratory sequential design. It consists of a qualitative phase designed to gain an understanding of the psychology of consumers of cloth items. This information was then employed in a quantitative phase that included psychological as well as non-psychological determinants of consumers' purchasing decision. The results revealed important insights in terms of business strategies that may be implemented to increase the demand for clothing by young and adult people.

Keywords: Consumers' behaviour; Clothing; Psychological factors.

Examining spatial price linkages in major EU Olive oil Markets through a Systematic Map

Pamela TheofanousA; Ourania TremmaA; Vasilis GrigoriadisB; Louise ManningC;

Keith WalleyD; Dimitrios PaparasA and Karl BehrendtA

Abstract

Olive oil is one of the healthiest edible vegetable fats and in recent years it has been climbing in consumer preferences due to its widely known health benefits. The EU represents approximately 70% of the global olive oil production, where the vast majority of the EU olive oil production originates from Spain, Italy and Greece; thus, it is also known as "The Essence of the Mediterranean". In 1993 the EU Single Market was established, aiming to integrate markets, however some discrepancies are still present in the price behaviour among them. This study investigates spatial price linkages in major EU Olive Oil markets through the application of systematic mapping, in order to analyse market efficiency, establish possible asymmetries in price transmission and define their potential causes. The aim of the systematic map is to collate evidence of existing literature that studied spatial price transmission in edible oils. The results showed 29 articles that studied price transmission in relation to edible oils, where 10 of these focused on spatial price transmission. There are mixed signs regarding the presence of asymmetries in spatial price transmission in edible oil markets, and the main causes of asymmetries appear to be market power and transaction costs. The findings from the systematic map indicate a gap in the literature on studies that focus on the olive oil market, since only two analysed spatial price transmission in olive oil markets within the EU.

Keywords: Spatial price transmission; olive oil; price asymmetries; systematic map; market integration

An investigation of differential requirements to develop the appropriate skills across members of organizations

Patricio Pesce Quezada

Abstract

The objective of this article is to present evidence revealing that optimal results in any organisation (e.g. education, social work, business, etc.) can be achieved by giving workers differential treatment according to their abilities and skills. The research was applied in the area of education considering two well differentiated individuals: those who required reinforcing basic performance skills; and those who already have the skills and competencies for determined tasks. Performance was then assessed by means of differentiated strategies using the same evaluating instrument. Using this strategy, both groups made progress in their academic abilities with positive externalities in terms of welfare and psychology.

Keywords: Differential treatment; skills; cognitive abilities.

A STUDY OF PEOPLE'S INDEBTEDNESS IN THE LAGOS REGION OF CHILE BEFORE AND DURING THE PERIOD OF HEALTH CRISIS COVID-19

Paulina Bahamonde and Javiera Velásquez

Abstract

Debt is the action of getting into debt that is related to payment obligations to a third party, with a commitment to pay for a specific amount and time. This action can be carried out by individuals, companies or a country. With regard to indebtedness in Chile, it is an action that in particular has increased several years ago and, in turn, has become quite relevant both for companies and for Chilean families, since it is the means they seek to access to satisfy your needs, new horizons, for investment, among others. Due to all of the above, there are many doubts that arise, such as what are the factors that really determine that a person gets into debt? Questions that arise even more due to the crisis scenario, where people's lifestyles have changed. Therefore, needs, tastes, motivations, income, among other determinants, are totally different from those used to. In relation to the above, the main purpose of the research is to identify how the people of the Los Lagos Region adjust their indebtedness patterns, under the scenario of a health crisis (COVID 19), in addition to knowing the level of indebtedness itself. On the other hand, the scenario in which the research was carried out was in a specific period of time, in which questions were involved from the beginning of the pandemic until November 2020 (during the pandemic), this scenario will allow contrasting the results with information obtained before the crisis, and during it, and thus see if these patterns have changed. In order to carry out the research, the observation was carried out using an econometric model, therefore, the study used a sample of 386 surveys of people from the Los Lagos Region, in this way, it was possible to identify the factors that directly influence the indebtedness of people, whether economic or financial factors, among others. The data were collected online and the software for the analysis was, in the first instance, the IBM SPSS Software, to perform the factorial analysis of Likert variables, and later to perform the multiple regression model in the EViews software, in which the most significant factors.

Keywords: indebtedness; COVID 19; crisis.

A Study of the Impact of Educational Levels on Innovation Development

Valeria Serpa and Isabel Nuñez

Abstract

Innovation is undoubtedly a concept that plays a key role as an engine of economic growth. However, there are several factors that condition its development, one of these being education at the global level, making it impossible to understand the individual contributions of each constituent level of the educational system. The purpose of the current research is to determine the educational level that promotes innovation, generating new knowledge and contributing to the analysis of the government management of 38 countries, based on a generalized least squares multiple regression. The results revealed that the type of education that maximizes the results of innovation, and was prominent with respect to other types, was technical education. This suggests that governments' effort to promoting primary and secondary education will not make a significant impact before restructuring the educational system putting more emphasis in technical education.

Keywords: Educational levels; technical education; innovation; economic growth.

Impact of Covid-19 on consumption patterns in Puerto Montt

Valeria Vera and Daniela Villarroel

Abstract

The current pandemic has caused major changes in the way people carry out their consumer activities. However, little is known about the key factors that explain these changes. The objective of the current research is to present the results of an investigation based on a mixed methodology of the exploratory sequential design carried out in the city of Puerto Montt, Chile. The results revealed that consumption patterns in this city were not only influenced by economic variables, as is normally argued, but also by sociodemographic and psychological factors, information that has been used to propose beneficial strategies for companies that have strongly been affected by the pandemic.

Keywords: Consumption patterns; market strategies; economic factors; socio-demographic factors; psychological factors; pandemic.

Explaining Lack of agricultural trade liberalization: A network approach

Daniel May

Abstract

This article explores theoretically the role of intermediaries in the supply chain of agricultural goods to explain lack of agricultural trade liberalisation. For this purpose, an international trade network approach was employed. By considering the market power that these firm cause in the supply (i.e. oligopoly and oligopsony), it was found that the presence of intermediaries reduces the likelihood of global free trade. Policy implications obtained from the results are also discussed.

Keywords: Trade agreements; intermediaries; market power.

The relationship between US corn, crude oil and Ethanol Prices

Ourania Tremma

Harper Adams University

Abstract

The present study aims to explore long and short-run linkages between corn-ethanol and corn-crude oil price pairs. Evidence from literature supported a degree of dependency between the price pairs providing indications for the influence of biofuel policies on price behaviour. Thus, this study investigated long and short run price relations through linear and nonlinear cointegration techniques accounting for structural breaks. The direction of causality was tested through Granger causality test and results supported a long run linear relation between the examined pairs. Moreover, policies appeared to have a significant effect on the long run relation whereas corn prices appeared to granger cause crude oil and ethanol prices. Lastly, results from MTAR model supported no evidence of asymmetries in the long and short run price transmission process.

Keywords: corn-ethanol and corn-crude oil price pairs

Imperfect competition in the Chilean wine market: a qualitative research

Geraldine Carrasco, José Castillo and Daniela Hernández

Austral University of Chile, Puerto Montt

Abstract

The purpose of this research was to identify the existence of imperfect competition in the supply chain of the wine industry in Chile by means of qualitative analysis applied a number of farmers and agricultural organizations. The results revealed significant imperfection and also farmers' lack of incentives to counterbalance the power exercised by powerful intermediaries. This result suggests that in order to make the wine sector more competitive, policy intervention is needed.

Keywords: Imperfect competition in the supply chain of the wine industry in Chile

Demand for Money in the United States: Stability and Forward-Looking Tests

Amir Kia
Finance and Economics Department Utah Valley University, USA

Abstract

This paper shows that demand for money, besides interest rate and personal consumption, is a function of fiscal variables like deficits, debt as well as foreign-financed debt and it is stable over the short and long run. It was found that agents in the market are forward-looking, and their expectations are formed rationally. This also means that even though the parameters of money demand are stable according to the stability test results they can be unstable as agents change their behaviour for any change in the policy. This means the contemporaneous policy variable is not super-exogenous.

Keywords: Demand for money, policy regime changes, forward-looking agents, stability

Drivers of Drug-Related Financial Crime and Some Short-Term Predictions

Morrison Handley-Schachler

Edinburgh Napier University

Abstract

Drug-related crime can be categorized by the nature of the drugs involved, that is, whether they are illegal, legal on prescription only or legal without prescription, or by the time when the crime is committed, that is, by whether the crime is committed before, during or after the consumption of drugs. Crimes committed before the consumption of drugs include illegal cultivation, smuggling, excise evasion, counterfeiting and crimes of violence in establishing local supply monopolies. Crimes committed in the act of consumption are those which involve the use of drugs which are illegal in themselves or by minors for whom the drugs are illegal. Crimes committed after the consumption of drugs include crimes of violence resulting from a mental state which has been artificially altered by drug use and the illegal operation of vehicles and machinery while intoxicated. Enforcement efforts in response to illegal drugs have largely focused on crimes committed by suppliers before consumption and these efforts ignore the need to cut off demand. This approach is often driven by class and racial discrimination, which creates a reluctance to punish middle class members of privileged ethnic groups for creating the demand side of an industry in which less privileged people are forced into the supply side by social pressure, exploitation by organized crime and lack of alternative economic opportunities.

The late twentieth century saw the rise of designer drugs (novel psychoactive substances), which are designed in part to create more powerful sensations of intoxication and in part to avoid legislation aimed at specific substances. These substances, including flualprazolam, have been a causal factor for numerous post-consumption crimes including sexual assault and driving while intoxicated and have also been implicated in fatal overdoses, murders and suicides. It is predicted that the supply and demand for these drugs will increase, partly from a desire by users to experiment and partly in repeated efforts to avoid legislative prohibitions on specific substances. The practice of framing legislation in terms of prohibiting specific substances is likely to be ineffective in many cases. This legislative approach may be described as putting up a fence to keep the trees out, as it is designed to appear effective in the very short term while in fact being completely ineffective and doomed to failure. Because of this and because of other factors such as libertarianism and potential tax revenues, a legislative retreat is forecast, with a far more permissive attitude to drugs than was applied in the 20th Century.

In times which present a combination of general economic well-being with social stress and political conflict, groups of disaffected individuals may turn to consuming drugs which give rise to unusual and extreme combinations of pleasure and discomfort, often in combination, not only as a form of escape from social pressure but also as a form of protest. The continued social and political stresses of the twenty-first century and social dislocation and mental stress caused by the COVID-19 pandemic may therefore be expected to give rise to an increase in the consumption of the most powerful hallucinogenics, which are often novel psychoactive substances. This would be analogous

to the rise of the flagellants in Italy in the mid-13th Century, which was likewise a time of economic prosperity accompanied by social and political tension. The rise of designer drugs is also analogous to the rise of the flagellants in being partly designed to skirt around legal prohibitions in the same way as the flagellants indulged physical and psychological appetites while ostensibly avoiding activities prohibited by Christian moral codes.

Food Waste/ Loss Reduction

Ghada Gomaa A. Mohamed

Research Chair; ECO-ENA: Economics & ECO-Engineering Associate, Inc.

Dean; Forward Academy

gmohamed@eco-ena.ca, ghada@forwardacademy.us

Abstract

This research work aims to compile all literature that focuses on food waste/ loss reduction and link them to theories of social welfare. The research seeks to be a treasure hold of an encyclopedia on food waste/ loss reduction that will be adopted by ECO-ENA, Inc., Canada, as one of its new interdisciplinary research projects.

Keywords: Food waste reduction, Food loss reduction, United Nations Programs, FAO, Consumer behaviour, Consumption theories, production theories, social welfare.

www.eco-ena.ca

Executive director: Dr. Ghada G. Mohamed