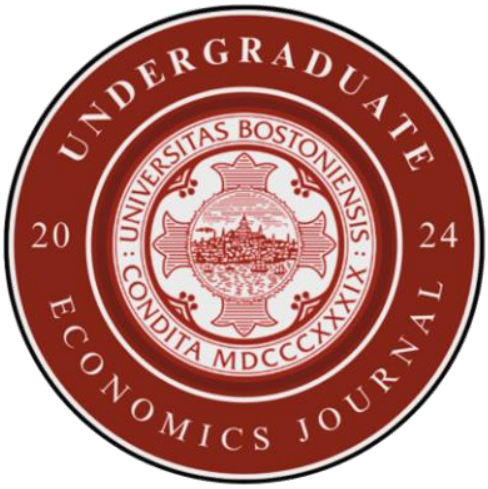
BOSTON UNIVERSITY UNDERGRADUATE ECONOMICS JOURNAL

SPRING 2024 ISSUE I VOLUME I



SPRING 2024 ISSUE I | VOLUME I

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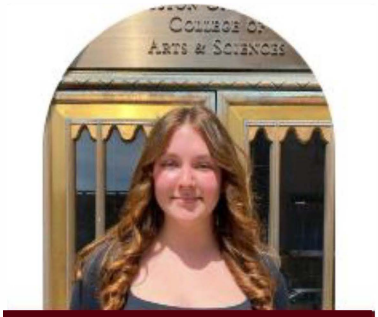

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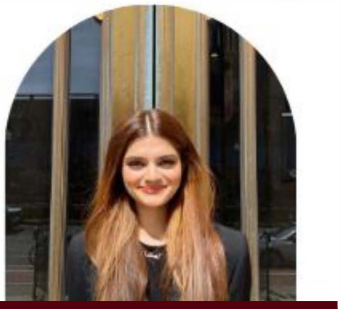

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STATEMENTS

STACEY GELSHEIMER
-FACULTY ADVISOR-

First, I would like to offer my congratulations to the team of students in the UEA who worked hard to make this first issue a success. Putting together and publishing an undergraduate journal in economics is hard work, and the dedication of students involved was obvious from the start. This is an amazing opportunity and potentially a historic event for the Department of Economics at Boston University. As we strive to continue to grow the number and availability of undergraduate research opportunities, having a group of students dedicated to the same mission is likely to spur the growth and development of our program as one that inspires a love of research and empirical economics in our undergraduates. This journal then provides an opportunity for these students to showcase their work, not only to our own faculty, but also to audiences beyond our university.

It is my honor to be the journal's first faculty advisor. hat I have seen from the students involved is an absolutely amazing set of talents, perseverance, dedication and willingness to work hard to get it right. I am extremely proud of them and hope to help continually develop the strengths these students already possess while also engaging with our department's faculty who are constantly encouraging, promoting and cultivating high-quality work from our undergraduates. Congratulations, and here's to many more issues!

MARC RYSMAN
-DEPARTMENT CHAIR-

Generating new research is central to the educational experience at the BU Department of Economics. I am delighted to see our student research celebrated by the new Boston University Undergraduate Economics Journal. The articles combine economic ideas with sophisticated econometric analysis to shed new light on important economic policies. Entirely conceived and created by our undergraduate student club, the journal is itself an expression of the creativity and ambition of our students. This new journal marks a new and exciting moment for the department and our students and is indicative of the dynamic intellectual environment in our department.

STATEMENTS

Letter from UEA President

The Undergraduate Economics Association (UEA) strives to proliferate engagement in the discipline of economics. In doing so, we seek to inspire individuals to be more thoughtful decision makers. The discipline foundation is rooted in human behavior, but also mathematics. By strict application of statistics, we infer truths regarding human behavior to guide political decision making. Generally, because of the rigor of the discipline's analysis, we find this practice most purely exercised by our graduate students. Though knowledge is democratic and accessible to all those who commit themselves to its study. The specific aim of our involvement in the journal is to showcase the efforts of students who've committed themselves to the discipline's fundamental practices; applying rigorous mathematical tools to uncover consequential insights.

We're incredibly proud of the work of all the individuals involved, especially in creating this inaugural issue. Having ideas is nice, but turning those ideas into reality takes high levels of coordinated effort from a variety of individuals. The BUUEJ team exemplifies this ability, and our undergraduate community is incredibly indebted to their efforts. No other team will be known as the founding members of the journal, and we hope that's adequate distinction. Further, I am personally grateful to this team for realizing this project; words fail in capturing that sincerity.

Much love,
Faisal
President of the Undergraduate Economics Association

Disclaimer

The content published in this undergraduate economics journal at Boston University is soley intended for educational and informational purposes. The views and opinions expressed in the articles, essays, and other submissions belong to their respective authors and do not necessarily reflect the views of Boston University, its faculty, staff, or administration. The accuracy and completeness of the information presented within these pages are not guaranteed, and readers are encouraged to conduct further research and consult professional advisors as needed.

All graphics and covers were designed by Senior Layout Editor, Rutuja Kharate.

ACKNOWLEDGMENTS

The first edition of Boston University's Undergraduate Journal of Economics would not have been possible without the generous support of the students and faculty of the Boston University Economics department. We are deeply appreciative of Department Chair Marc Rysman for his ongoing encouragement of this publication. We are also incredibly grateful for the indispensable leadership and moral support provided by Senior Lecturer Stacey Gelsheimer. The production of this edition did not come without hurdles, and we thank Chair Rysman and Professor Gelsheimer for their guidance and their unwavering confidence in our team.

We are thankful to have had the privilege of being assisted by several faculty in the procurement of the papers within this edition. For this assistance we would like to recognize Senior Lecturer Ishita Dey, Professor Regina Cati, and Senior Lecturer Bjorn Persson. We would also like to recognize Professor Robert G. King and Professor Juan Ortner for their thoughtful suggestions on the complex matters of refereeing.

We are profoundly indebted to the efforts of the Boston University Undergraduate Economics Association E-Board. Without them, this publication and the creation of the editorial team would never have come to fruition. Of particular mention are the following: President Faisal Ahmed for his vital leadership and guidance; Director of Operations Varshitha Kumar for never failing to go truly above and beyond in her initiative to make this edition a reality; Director of Communications Aini Zhou for creating alignment between the E-Board and the editorial team; to Director of Research Tadeas Nanjo and Executive Vice President Annie Chan, for planning the journal launch event and assembling the editorial team. Regarding the assembling of the editorial team, we would also like to thank Amy Fam and Morgan Fleming who are both members of the Executive Board for Boston University's Undergraduate Women in Economics.

We would like to acknowledge and celebrate the students on the editorial team for their countless hours of hard work to ensure the highest quality of this edition. The team members we would like to commemorate are, in no particular order: Copy Editor Aeddon Burns for his commitment to the excellence of this edition; Layout Editor Rutuja Kharate for her efforts in organizing not only the issue itself, but team objectives as well; Senior Editor Madison Roost for her impressive and contagious work ethic; Senior Editor Ajay Raman for his outstanding editorial capability; Senior Editor Ellie Wang for her thoughtful and considered confidence; and Layout Editor Arnav Swamy who, although joining later in the process, provided irreplaceable assistance to the quality of the product. All mentioned have been equally phenomenal additions to the team and we are incredibly indebted to their extensive contributions.

The following pages contain a treasure trove of intellectual exploration, a testament to the boundless potential and scholarly acumen of our undergraduate students. Herein dynamic and fresh insights have been meticulously crafted into essays which stand as beacons of inspiration, illuminating the power of undergraduate research in our department. It is a tribute to the collaborative spirit, intellectual curiosity, and relentless pursuit of knowledge that permeate our community. As you embark on this journey of exploration and discovery, may you be inspired by the depth of insight, the breadth of inquiry, and the limitless possibilities that await within these pages.

Sincerely,
Kiernan Gallaher
Editor-in-Chief

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AN EXPLORATION OF HORIZONTAL MERGERS USING STOCK PRICES

Varshitha Sathish Kumar

This paper explores the efficacy of horizontal mergers across four major industries – pharmaceutical, banking, airline, and gaming – with a focus on discerning possible collusive actions through mergers' effects on stock prices in non-merging, rival firms. My research seeks to determine whether these changes are suggestive of collusion-based synergies or traditional (and legal) efficiency-based synergies. Using the concept of abnormal returns, my research details the dynamics of competition occurring within these industries and offers valuable insights for regulators and market participants alike. Furthermore, my work attempts to resolve the dearth of comprehensive assessments of horizontal mergers and sheds light on potential collusive actions and their far-reaching consequences.

I. Introduction

Horizontal mergers occur when two companies operating in the same or similar industries combine their businesses. Merging companies are typically competitors offering similar products or services and a merger can have attractive consequences including *economies of scale*, improved efficiency, and increased market power. That said, these mergers can also raise antitrust concerns as they may reduce competition within the industry as a whole by raising the industry's *concentration level*. As a theoretical principle, economists have frequently acknowledged the potential for a relationship between a growing industry concentration and the possibility of collusion, whether this be implicit or explicit. For example, the Cournot-Nash model of firm interaction emphasizes that the equilibrium price rises as the number of firms declines.[1] As a result, regulatory bodies regularly scrutinize horizontal mergers to ensure they do not contribute to anticompetitive behavior that would harm consumers.

Typically, the ramifications of a merger are analyzed through its effect on the concentration of the market in addition to the cost efficiency the merging firms gain through it. Per guidelines outlined by the Department of Justice (DOJ), market concentration is evaluated using the *Herfindahl-Hirschman Index* (HHI). The DOJ categorizes markets broadly into three types based on their HHI values: Unconcentrated Markets (HHI below 1500), Moderately Concentrated Markets (HHI between 1500 and 2500), and Highly Concentrated Markets (HHI above 2500). These classifications are useful in identifying mergers with possible concerns surrounding competitiveness. The difference in HHI in an industry following a merger is used to identify and assess potential problems. The thresholds specified by the DOJ help identify mergers warranting closer scrutiny for potential adverse effects on competition.[2]

Despite challenges that exist in distinguishing between gains from efficient production following a merger (so-called *efficiency-based synergies*) and those arising from an expansion in market power (*collusive synergies*), the two concepts are fundamentally different. While collusive synergies are characterized by market power manipulations that contribute to reduced competition, efficiency-based synergies arise by combining the production capabilities, distribution networks, and operational resources of merging firms to reduce costs and increase productivity. Efficiency based synergies may become more efficient through a factor like *economies to scale*. This term refers to the process by which larger production volumes can result in lower average costs per unit, allowing a newly merged entity to produce goods or services more efficiently. This efficiency can enhance the competitiveness of the merged firm, benefiting consumers through lower prices or improved product quality. On the other hand, streamlined operations and shared resources from a merger can also lead to enhanced innovation and a greater ability to adapt to market changes which serves to further strengthen the overall efficiency of the merged entity.

Despite their differences, each case can involve a positive effect on profits which might indicate the presence of positive synergies but cannot make a distinction between whether this

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[1] Stillman, Robert. "Examining Antitrust Policy towards Horizontal Mergers." *Journal of Financial Economics* 11, no. 1–4 (1983): 225-240.

[2] Department of Justice. "Horizontal Merger Guidelines." Accessed, November 20, 2023, https://www.justice.gov/media/810916/dl?inline.

synergy is collusive or efficiency-based in nature.[3] In order to properly recognize potentially anti-competitive characteristics of mergers, one salient approach involves carefully scrutinizing the pricing behavior of rivals. A closer examination of changes in rivals' prices can serve as a crucial signal for determining whether positive effects to profits may be a consequence of augmented market power as opposed to one of increased efficiency. This method provides one way of exploring merger behavior and is useful in allowing one to better recognize consolidation within industries arising from market power manipulation.

The importance of collusion theory lies in what it implies for changes to relative product (and factor) prices induced by mergers. By recognizing that shifts in product prices subsequently trigger fluctuations in the market value of the firms engaged in these transactions, the attention is redirected to the abnormal stock returns associated with the merging entities and their horizontal competitor.[4] The potential benefits arising out of a merger – specifically, enhanced competitiveness – can be assessed by the stock market's reaction to the firms' announcements of the merger. If the public anticipates that a merger will increase the resource portfolio of the merging firms, thereby strengthening its competitive position, abnormal negative returns are expected for rivals. Conversely, if a merger is anticipated to lessen competitive intensity, one would expect that rival firms would enjoy abnormal positive returns. Intuitively, the reduction in competitive pressures is viewed as being advantageous to the rivals' performance.[5]

The rest of this paper will proceed as follows. First, I explore extant literature to establish the existing theoretical framework concerning interplay between the stock prices of rivals to the merging firms and the ensuing repercussions of the mergers. Following this, the paper lays the groundwork for a more concrete understanding of these dynamics. I employ an event-study procedure, scrutinizing mergers from a diverse set of 30 firms spanning numerous industries that include the pharmaceutical, banking, airline, and gaming sectors. The results are thoroughly examined, and the paper concludes with a discussion of the relevance of my findings and a dialogue suggesting areas for future research.

II. Literature Review

Researchers have frequently tried to formally demonstrate the ways in which mergers between firms derive value. Chatterjee's framework, for example, describes "three broad classes of resources that contribute to the creation of value [including those classified] as cost of capital related (resulting in financial synergy), cost of production related (resulting in operational synergy), and price related (resulting in collusive synergy)." Chatterjee finds that "collusive synergies tend to have the highest associated values," underlining their importance in the merger landscape.[6]

Research carried out by Clougherty and Duso has contributed to the categorization of

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[3] Clougherty, Joseph A., and Tomaso Duso. "Using Rival Effects to Identify Synergies and Improve Merger Typologies." Strategic Organization 9, no. 4 (2011): 310–335. https://journals.sagepub.com/doi/pdf/10.1177/1476127011421536

[4] Eckbo, B. Espen. "Horizontal Mergers, Collusion, and Stockholder Wealth." *Journal of Financial Economics* 11 (1983): 241-273. North-Holland Publishing Company. Received November 1981, final version received May 1982.

[5] [5] Stillman, Robert. "Examining Antitrust Policy towards Horizontal Mergers." *Journal of Financial Economics* 11, no. 1–4 (1983): 225-240.

[6] Chatterjee, Sayan. "Types of Synergy and Economic Value: The Impact of Acquisitions on Merging and Rival Firms." *Strategic Management Journal* 7 (1986): 119-139.

mergers based on an analysis of both merging and rival firms. Their classification distinguishes between collusion-based and efficiency-based synergistic mergers, representing two value-increasing M&A types for merging firms. They further identify non-synergistic and value-destroying mergers, two value-decreasing M&A types for merging firms. Using stock market data and an event-study methodology encompassing large horizontal mergers in the US, UK, and Europe, they carefully describe the dynamics shaping merger events.[7]

In his research, Bjorn Espen Eckbo investigates whether horizontal mergers contribute to positive abnormal returns for shareholders of both bidding and target companies. Specifically, he explores this possibility as the result of successful collusion among competing producers. His dataset is comprised of detailed information on horizontal mergers within the mining and manufacturing sectors. He also includes a 'control' sample consisting of vertical mergers that occur in the same industries to analyze variations in returns. These findings reveal that, on average, rivals of contested horizontal mergers experience significantly positive abnormal returns following the announcement of a merger proposal.[8] To demonstrate a reduction in consumer welfare resulting from a horizontal merger, it becomes vital for rival firms to observe and document a rise in value during events that increase the likelihood of the merger occurring and a fall in value when the likelihood of the merger diminishes. His paper uses daily stock return data from a sample of rivals to 11 horizontal mergers to test this idea.[9]

My research here intends to draw primarily on Eckbo's methodology while integrating the system of categorization described by Clougherty. Using this "merger" of frameworks, the work that follows systematically classifies mergers and empirically evaluates changes in rival stock prices following the announcement of mergers.

III. Data and Descriptive Statistics

The sample comprises significant horizontal mergers in the American product market between 2007 and 2021 identified through Wall Street Journal merger announcements and press releases. Some mergers underwent review by the Federal Trade Commission (FTC) and the Department of Justice (DOJ), facilitating the necessary identification of relevant competitors. For other mergers, firms operating in the same product market as the merging entities were considered rivals.

My work investigates trends across four industries. In the banking industry, competitive rival banks were selected based on market share data from the Federal Deposit Insurance Corporation (FDIC), leading to the analysis of 10 banks to fully understand the nature of the effects on competition. For the airline industry, major rivals were identified using news and press releases from the Wall Street Journal and 9 airlines with significant market share were selected for consideration. For the pharmaceutical and gaming industry, rival firms were identified through articles in the pharmaceutical industry and the gaming industry leading to the selection

[7] Clougherty, Joseph A. "Using Rival Effects to Identify Synergies and Improve Merger Typologies." [8] Eckbo, B. Espen. "Horizontal Mergers, Collusion, and Stockholder Wealth."

[8] Eckbo, B. Espen. "Horizontal Mergers, Collusion, and Stockholder Wealth."

[9] Stillman, Robert. "Examining Antitrust Policy towards Horizontal Mergers."

of 6 and 5 firms, respectively.[10, 11]

I utilized Yahoo Finance for data relating to stock prices with relevant S&P industry indices used for all industries except banking which instead utilized the Nasdaq Composite. Specifically, data on the Adjusted Close price was collected to calculate daily stock returns ($R_{i,t}$) and market return ($R_{m,t}$) for all merging and rival firms. Additionally, information for each firms' industry sector index was collected (where *i* refers to the firm, *m* to the specific sector, and *t* to time). The growth column was constructed by making use of daily close prices for both individual companies and the S&P industry index. This column captures daily growth patterns using the standard formula for change: "[(today's stock − previous) / [previous]" and serves as a crucial variable for estimation.

IV. Empirical Model

Regression Model

A well-known framework within finance, the capital asset pricing model (CAPM), is used to estimate a market model of each firm's stock returns (R_{it}).

$$\boldsymbol{R_{it} = \alpha_i + \beta_i R_{m,t} + \epsilon_{i,t}}$$

where R_{it} denotes the daily return of firm i on day t, $R_{m,t}$ represents the corresponding daily return for the S&P industry index, α_i and β_i are firm specific parameters, and $\epsilon_{i,t}$ is the error term. The coefficient β_i reflects systematic co-movements of security i's return with the return on the market portfolio while the serially uncorrelated, zero mean error term, $\epsilon_{i,t}$ captures the impact of non-market factors (industry specific characteristics) and random price fluctuations.

Abnormal Returns Calculation

In the context of an event study on mergers, I begin by estimating this model using a historical time period to determine the "normal" relationship between the individual stock and the market. Then, I use the estimated model to calculate the "normal" expected returns during the event window (the period around the merger announcement). Utilizing STATA for the event study, the model is used to calculate abnormal returns ($AR_{i,t}$) based on the Capital Asset Pricing Model (CAPM), *i.e.,* by using the estimated coefficients, α_i and β_i to predict daily return for each firm i over the event window. This method allows me to isolate abnormal performance by contrasting the actual returns with expected returns based on the market model.

$$\boldsymbol{AR_i = R_{it} - \hat{R}_{i,t}}$$
$$\boldsymbol{AR_i = R_{it} - (\alpha_i + \beta_i R_{m,t})}$$

[10] Dunleavy, Kevin. "The Top 20 Pharma Companies by 2022 Revenue." April 18, 2023.https://www.fiercepharma.com/pharma/top-20-pharma-companies-2022-revenue

[11] "43 Gaming Companies You Need to Know" accessed on December 5, 2023 https://builtin.com/gaming/gaming-companies

Here, $R_{i,t}$ represents the actual return for firm *i* on day *t*. $R^{\wedge}_{i,t}$ is the counterfactual return assuming no merger announcement. The counterfactual return ($R^{\wedge}_{i,t}$) is calculated as $\alpha_i + \beta_i R_{m,t}$.

Time-Window Analysis

Abnormal returns were aggregated over a predefined time period centered around the merger announcement. The specific duration of this event window was selected to best capture relevant market dynamics and evaluate the impact of the merger on stock performance.

The Cumulative Abnormal Return (CAR), or simply the sum of abnormal returns, is the sum of daily abnormal returns within a specific event window spanning from τ_1 to τ_2.

$$\boldsymbol{CAR_{i,\tau_1,\tau_2}} = \sum \boldsymbol{AR_{i,t}}$$

Given that the focal point is the influence on a collective of companies, a cross-sectional aggregation becomes essential, allowing for the computation of AAR.

$$\boldsymbol{AAR_t} = \frac{\boldsymbol{1}}{\boldsymbol{N}} \sum_{\boldsymbol{i=1}}^{\boldsymbol{N}} \boldsymbol{AR_{i,t}}$$

where $AR_{i,t}$ represents the AR estimated on the ith security and N, the securities' population. The cross-sectional aggregation of ARs is reasonable given my intention of studying whether the merger announcement alters, on average, the stock price. When the focus is on the average effect over multiple days, it is necessary to aggregate and compute the CAARs by summing the AAR over time.

$$\boldsymbol{CAAR(t_1, \tau_2)} = \sum_{\boldsymbol{t=\tau_1}}^{\boldsymbol{\tau_2}} \boldsymbol{AAR_t}$$

Again, using STATA, the event study command *estudy* does this automatically.[12] This event study model rooted in the CAPM provides a robust framework for exploring the impact of merger announcements on stock returns.

V. Model Formulation

Using basic insights from the industrial organization (IO) model, a framework to classify mergers can be developed.[13] As mentioned previously, my research here uses the methodology developed by Clougherty to classify mergers into one of the four categories: collusion-based and efficiency-based synergistic mergers or non-synergistic and value-destroying mergers.[14]

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[12] "The Stata Journal. "Event study estimations using Stata: The estudy command." *The Stata Journal 18* (2018): 461–476.

[13] Tirole, Jean. "The Theory of Industrial Organization." Cambridge, MA: MIT Press.(1992).

[14] Clougherty, Joseph A. "Using Rival Effects to Identify Synergies and Improve Merger Typologies."

Industrial organization typically focuses on the nature of competition (prices and quantities) in imperfectly competitive markets. Strategic interactions between firms, *i.e.*, mergers, in these markets can be linked to the profitability of competitor firms.[15] A certain degree of interdependence between firms forces them to adapt their market strategies when competitor firms take their own strategic actions and frequently has direct and important implications with regard to identifying the merger types.[16] Here, I classify mergers in more detail:

1. **Efficiency-based Synergistic Mergers:** An IO framework asserts that efficiency gains post-merger derive from cost-reductions. If a horizontal merger is deemed an efficiency-based synergy, it increases the profitability of the merging firms but will tend to decrease the profits of the rival firms, *i.e.*, it will exert a *negative externality* on rival firms' profitability. Efficiency-based synergies in mergers include the development of both economies of scope and scale in addition to skill and resource sharing. Additionally, management research, which might include resource heterogeneity and immobility, extends beyond cost-based synergies to focus specifically on the resources of the acquiring firm that provide new products, assets, and skills, contributing to a competitive advantage for the newly merged entity.[17]

2. **Collusion-based Synergistic Mergers:** The IO framework also discusses the notion of collusion-based synergistic mergers. Following a reduction in the number of competitors in a market, there might simply be higher prices and profits as a result of decreased aggregate output.[18] Unlike the negative effect seen under efficiency-based mergers, collusion-based mergers exert a *positive externality* on rival firms' profitability. As a result, such a merger increases the profitability of both the merging firms *and* rival firms. Under these mergers, direct competition between large companies is eliminated causing the aforementioned profits increases seen by both the merging firms and their rivals. Occasionally, mergers between firms can lead to losses or negative profit due to factors like managerial incentives which might include something like empire-building or biases in managerial expectations. Despite the common assumption that merging firms always stand to gain from mergers, the occurrence of *value-decreasing* mergers underscores that losses can sometimes outweigh potential gains, contributing to an overall loss for the merging firms.

3. **Non-Synergistic Mergers:** In the context of non-synergistic mergers, the anticipated synergies that drive the perceived profitability of a merger may not materialize.

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[15] Perry, Martin K., and Robert H. Porter. 1985. "Oligopoly and the Incentive for Horizontal Merger." American *Economic Review* 75 (1): 219-227.

[16] Chen, Ming-Jer. "Competitor Analysis and Interfirm Rivalry: Toward a Theoretical Integration." *The Academy of Management Review 21,* no. 1 (January 1996): 100-134. https://doi.org/10.2307/258631.

[17] Barney, Jay B. "Strategic Factor Markets: Expectations, Luck, and Business Strategy." *Management Science 32* (1986): 1231–1241.

[18] Deneckere, Raymond, and Carl Davidson. "Incentives to Form Coalitions with Bertrand Competition." *RAND Journal of Economics* 16, no. 4 (1985): 473-486.

Consequently, a merger that initially appears lucrative may ultimately prove to be unprofitable if the expected synergies fail to present. The value-decreasing nature of such mergers can create competitive opportunities for improving rival firm profitability and performance.[19] Therefore, such mergers generally decrease the profitability of merging firms and increase the profitability of the rival firms.

4. **Value-Destroying Mergers:** In certain mergers, significant efficiencies may be achieved that do indeed contribute to a negative impact on rival firms' profitability. Nevertheless, substantial integration costs arising from attempts to merge disparate corporate cultures can result in value-destroying outcomes. In such cases, the IO framework is frequently helpful in offering an enhanced understanding of mergers that prove unprofitable for both merging and rival firms.[20] When the losses incurred by the rival firms outweigh the losses of the newly merged firm, this is classified as a value-destroying merger.

Event Study Procedure

This paper uses stock price data from short-term windows to categorize the following mergers. The merit of employing a short-term window lies in its ability to attribute stock price changes more effectively to a specific event, minimizing the influence of potential confounding factors. Maintaining a narrow window ensures a certain level of protection against the outside influence of other significant shocks or events that may be the true source of abnormal return.[21] Although a three-day window is typical, I make use of an extended one given that my analysis not only includes a focus on the immediate effects felt by the merging firms but also effects on rival firms. Recognizing that it takes time for financial markets to assimilate the effects of a merger on the stock prices of rival firms – specifically, an understanding of the merger, calculation of market competition dynamics, and an assessment on the impact on rivals -justifies the use of this broader event window. I perform this analysis using STATA on the four previously mentioned industries. The estimation window lasts from the time at which information is first available up until the thirtieth trading day prior to the event (−30).

Next, I consider the Cumulative Average Abnormal Return (CAAR) for merging firms and rival firms over multiple time windows. The particular mergers and acquisitions are classified into the aforementioned merger types. Again, collusion-based synergistic mergers are those mergers that result in positive abnormal returns for both the acquiring and target firms alongside positive abnormal returns for rival firms. Efficiency-based synergistic mergers involve positive abnormal returns for merging firms (the acquirer and target) but result in negative abnormal returns for rival firms. Non-synergistic mergers encompass negative abnormal returns for merging firms and positive abnormal returns for rival firms. Value-destroying mergers involve negative abnormal returns for both merging firms and rival firms.

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[19] Amir, Rabah, Effrosyni Diamantoudi, and Licun Xue. "Merger performance under uncertain efficiency gains." *International Journal of Industrial Organization 27*, no. 2 (2009): 264-273.

[20] Fridolfsson, Sven-Olof, and Johan Stennek. "Why Mergers Reduce Profits and Raise Share Prices–A Theory of Preemptive Mergers." Published online on 13 December 2010. https://doi.org/10.1162/1542476054729455

[21] McWilliams, Abagail, and Donald Siegel. "Event Studies in Management Research: Theoretical and Empirical Issues." *Academy of Management Journal*, 1997, Vol. 40, No.3, 626-657.

VI. Description of Results

Airline Industry

On April 5, 2022, JetBlue Airways Corporation (NASDAQ: JBLU) announced its move to acquire Spirit Airlines Inc. (NYSE: SAVE).

Table 1-Abnormal returns to bidder, target, and rival firms in horizontal mergers relative to the merger proposal announcements

Event study with common event date
Event date: **05apr2022**, with **6** event windows specified, under the Normality assumption

SECURITY	CAAR[-10,10]	CAAR[-3,3]	CAAR[0,3]	CAAR[0,15]	CAAR[0,30]	CAAR[0,60]
ALGTA	5.00%	-0.11%	-0.72%	1.85%	8.22%	9.22%
ALK	-6.89%	-3.66%*	-1.60%	-11.54%***	-21.22%***	-18.33%*
HA	-8.30%	4.36%	1.88%	-18.74%**	-8.37%	13.71%
ULCC	-4.28%	6.26%	5.21%	-7.47%	-1.63%	43.23%**
LUV	-2.08%	-3.91%*	-4.49%***	-4.92%	-3.58%	-8.89%
AAL	5.56%	5.61%**	4.01%**	2.44%	7.75%	22.62%**
SAVE	-4.04%	30.43%***	31.39%***	5.23%	-8.57%	39.77%
JBLU	-22.74%***	-13.22%***	-11.85%***	-31.09%***	-35.23%***	-29.70%**
UAL	-4.40%	1.91%	2.80%*	4.72%	4.22%	12.32%
Ptf CARs n 1 (9 securities)	-4.43%	3.43%**	3.33%**	-6.16%**	-5.83%	10.24%
CAAR group 1 (9 securities)	-4.12%	3.51%**	3.38%***	-5.90%**	-5.46%	10.94%*

*** p-value < .01, ** p-value <.05, * p-value <.1

The results in Table 1 indicate that the target firm Spirit Airlines Inc. (NYSE: SAVE) generally earned a positive return following the announcement. The estimates in Column 2 indicate that, on average, shareholders of the target firm realized a 30.43% abnormal return over the six days period represented by CAAR[-3, 3]. The estimates in Column 3 suggest that, on average, shareholders realized a 31.39% abnormal return over the three-day period represented by CAAR[0, 3].

Turning our attention to major rival firms such as United Airlines Holdings Inc(NASDAQ: UAL) and American Airlines Group Inc (NASDAQ: AAL) also reveals a positive abnormal return trend. As suggested by the estimates in Column 3, United Airlines Holdings Inc experiences a 2.80% abnormal return over the three-day period represented by CAAR[0, 3] while American Airlines Group Inc records a marginally higher 4.01% abnormal return over the same period. These findings suggest that, unlike JetBlue Airways Corporation, the major rivals experienced positive market effects following the acquisition announcement, raising important questions regarding the competitive dynamic and potential strategic advantages across the airline industry.

United Airlines Holdings Inc and American Airlines Group Inc compete primarily with JetBlue Airways Corporation across many routes establishing these firms as major competitors. Hawaiian Airlines (Hawaiian Holdings, Inc. - NASDAQ: HA) and Alaska Air Group, Inc. (NYSE: ALK) hold a predominant presence in the Pacific region of the United States. Following the announcement of the proposed merger both United Airlines Holdings Inc and American Airlines Group Inc experienced negative returns. However, given that these firms are the primary competitors or rivals, it is reasonable to categorize the merger as a collusive-based synergistic merger. This categorization arises from the positive returns observed for both the rival firms and the merging firms. Additionally, it is important to highlight the remarkable 43.23% positive abnormal return experienced by Frontier Group Holdings Inc (NASDAQ: ULCC) suggested in

Column 6 over the sixty-day period represented by CAAR[0, 60]. Frontier, a low-cost carrier, is a major rival of Spirit Airlines Inc . The substantial positive return is highly indicative of the collusive nature of the merger.

Despite JetBlue Airways Corporation experiencing negative returns, it is important to temporarily overlook this aspect. Acquiring companies commonly experience a short-term dip in their stock value post-merger which can be attributed to factors like an acquisition premium, the use of cash reserves, or the assumption of new debts. This temporary decline, therefore, does not necessarily diminish the potential benefits gained merger, especially when one considers the broader context of the industry dynamics and competitive positioning. This was a valid concern and the DOJ consequently sued JetBlue Airways Corporation to stop this merger.[22]

Banking

On September 25, 2008, a merger was announced between JPMorgan Chase & Co. (NYSE: JPM) and Washington Mutual, Inc. (*formerly traded as* NASDAQ: WAMU).

Table 2-Abnormal returns to bidder, target, and rival firms in horizontal mergers relative to the merger proposal announcements

Event study with common event date

Event date: **25sep2008**, with **6** event windows specified, under the Normality assumption

SECURITY	CAAR[-10,10]	CAAR[-10,20]	CAAR[-3,3]	CAAR[0,15]	CAAR[0,60]	CAAR[0,200]
Jpmorgan	26.08%***	20.36%*	19.28%***	14.34%*	8.52%	57.50%*
BAC	-4.50%	3.44%	16.31%***	-8.12%	-29.03%*	59.72%*
WFC	17.57%*	20.96%*	14.77%***	12.42%	21.52%	60.77%
Citibank	6.44%	4.10%	20.46%***	5.50%	-15.08%	16.88%
ZION	40.53%***	41.21%***	-2.40%	27.17%***	15.50%	39.87%
KEY	-12.64%	37.67%***	9.37%	22.98%**	42.04%*	99.61%**
FITB	18.98%	26.25%*	-4.87%	14.48%	4.83%	144.69%***
RF	35.75%***	57.29%***	-30.88%***	29.94%***	40.18%*	106.13%**
USB	13.37%**	4.16%	10.50%***	0.23%	-7.83%	-8.51%
HSBC	-0.69%	-13.13%*	5.71%	-9.74%*	-39.42%***	-28.16%
PB	10.93%	1.27%	3.67%	11.19%*	3.85%	27.06%
Ptf CARs n 1 (11 securities)	17.26%***	23.92%***	6.98%***	14.94%***	11.50%	75.06%***
CAAR group 1 (11 securities)	16.84%***	23.69%***	6.69%***	14.68%***	11.98%**	76.78%***

*** p-value < .01, ** p-value <.05, * p-value <.1

The year 2008 was marked by a significant financial crisis that rocked the banking industry. During the crisis, the banking sector underwent a significant downturn that led to the collapse of nearly 200 banks and resulted in cumulative losses exceeding $3 trillion USD. Concurrently, around 740 mergers and acquisitions (M&A) occurred with certain transactions receiving backing from the U.S. government. Numerous bank mergers took place and included firms like Bank of America, Merrill Lynch, JPMorgan Chase, Bear Stearns, Wachovia, Wells Fargo, JPMorgan Chase, and Washington Mutual.[23]

The merger involving JPMorgan Chase & Co. and Washington Mutual, Inc. exhibits significant and sustained positive abnormal returns over the entire time period, implying a widespread belief among market participants that efficiency gains would result from the merger. The FDIC's approval and the absence of any contestation by the DOJ lend further credit to this perception. Also worth emphasizing is that the majority of rival banks also experienced positive

[22] Justice Department Sues to Block JetBlue's Proposed Acquisition of Spirit- Press Release. DOJ. https://www.justice.gov/opa/pr/justice-department-sues-block-jetblue-s-proposed-acquisition-spirit

[23] Maslak, G.D., Senel, G. "Bank Consolidation and Systemic Risk: M&A During the 2008 Financial Crisis." *Journal of Financial Services Research 63*, (2023), 201–220. https://doi.org/10.1007/s10693-022-00380-5.

abnormal returns surrounding the merger announcement and across various periods. Notably, key market competitors such as The Bank of America Corporation (NYSE: BAC), Citigroup Inc (NYSE: C), and Wells Fargo & Co (NYSE: WFC) also demonstrate positive returns.

Another noteworthy trend can be seen in the data when exploring the post-merger phase during the 200-day period in Column 6 represented by CAAR[0, 200]. During this period, all banks, including rivals, experience positive abnormal returns. This widespread financial upswing indicates that not only did merging banks thrive post-merger, but rival firms also reaped benefits. Given the government's primary objective in working to mitigate the effects of bad loans and improve profitability, this merger stands out as having been an efficient and successful strategy. In theory, the positive outcomes would tend to suggest a collusive-based synergistic merger. Despite this, a more nuanced understanding is needed that includes accounting for the sometimes drastic changes to the interest rate and consumer welfare over time, particularly as a result of the unique circumstances that were the Great Recession.

Pharmaceutical

On December 12, 2020, AstraZeneca plc (NASDAQ: AZN) announced its move to acquire Alexion Pharmaceuticals Inc (*formerly traded as* NASDAQ: ALXN) to accelerate their strategic and financial development.

Table 3-Abnormal returns to bidder, target, and rival firms in horizontal mergers relative to the merger proposal announcements

Event study with common event date

Event date: **12dec2020**, with **6** event windows specified, under the Normality assumption

SECURITY	CAAR[-20,10]	CAAR[-3,3]	CAAR[0,3]	CAAR[0,10]	CAAR[0,40]	CAAR[0,60]
ABBVV	4.74%	-1.99%	-1.54%	-3.12%	-4.61%	0.45%
AZN	-15.86%*	-6.45%*	-6.13%**	-9.84%**	-12.66%	-13.01%
GSK	-3.43%	-1.06%	-1.72%	-3.34%	-6.68%	-2.76%
JNJ	3.56%	-0.29%	-2.03%	0.07%	5.99%	3.76%
MRK	0.87%	-2.38%	-2.95%*	-2.49%	-12.50%**	-11.09%
PFE	4.23%	-10.46%***	-7.98%***	-10.73%***	-17.35%**	-14.97%
Ptf CARs n 1 (6 securities)	-1.00%	-3.76%***	-3.71%***	-4.91%***	-7.98%**	-6.34%
CAAR group 1 (6 securities)	-0.83%	-3.73%***	-3.69%***	-4.85%***	-7.76%**	-6.00%

*** p-value < .01, ** p-value <.05, * p-value <.1

This merger is best classified as a value-destroying merger. Both the acquiring firm, AstraZeneca plc, and rival firms experienced negative abnormal returns across various time windows following the announcement. AstraZeneca plc consistently demonstrated a negative cumulative average abnormal return throughout the observation period. While it is common for acquiring companies to undergo short-term falls in stock value post-merger – often attributed to factors such as an acquisition premium, the use of cash reserves, or the assumption of new debts – this pattern extended to all rival firms, suggestive of a broader market trend.

Contrary to general expectations regarding the anticipated outcome of pharmaceutical mergers, which frequently involve increases in concentration and concerns about potential misuses of market power, this merger involved neither. Specifically, the negative abnormal returns observed for both the acquiring firm and its rivals suggest complexities beyond the conventional fluctuations arising post-merger. One key fact to recognize is that December 14, 2020, marked the date at which vaccines for the COVID-19 were first available. This is an important factor that may have been expected to increase the returns for many of these pharmaceutical companies. Another key factor to consider is certain regulatory hurdles which can also explain the trend

amongst the firms shown in the table. Regulatory challenges and delays in obtaining necessary approvals for mergers and vaccinations can lead to negative sentiment among investors. Regulatory uncertainties can also create significant risks for companies.

Gaming industry

On January 11, 2022, Take-Two Interactive Software, Inc. (NASDAQ: TTWO) announced its move to acquire Zynga Inc (NASDAQ: ZNGA).

Table 4-Abnormal returns to bidder, target, and rival firms in horizontal mergers relative to the merger proposal announcements

Event study with common event date

Event date: **11jan2022**, with **6** event windows specified, under the Normality assumption

SECURITY	CAAR[-10,10]	CAAR[-3,3]	CAAR[0,3]	CAAR[0,15]	CAAR[0,30]	CAAR[0,100]
NTDOY	5.73%	-0.97%	-3.71%	1.68%	2.06%	-30.85%
EA	1.15%	-0.89%	2.21%	10.45%	5.97%	33.59%
SONY	-6.19%	-0.98%	2.27%	-4.58%	-9.22%	-0.57%
TTWO	-37.75%*	-17.26%*	3.41%	1.33%	-15.98%	-98.96%
TCEHY	27.40%*	19.10%**	9.40%**	26.85%*	34.62%*	112.44%*
MSFT	5.88%	1.81%	0.27%	6.45%*	12.01%*	34.60%*
Ptf CARs n 1 (6 securities)	-0.40%	0.27%	2.31%	7.19%	5.05%	9.59%
CAAR group 1 (6 securities)	-0.07%	0.41%	2.38%	7.46%	5.56%	11.65%

*** p-value < .01, ** p-value <.05, * p-value <.1

Subsequent to the initial merger between Take-Two Interactive Software Inc. and Zynga Inc, Microsoft Corp expanded its strategic footprint through its acquisition of Activision Blizzard Inc (NASDAQ: ATVI) on January 18th, 2022. The analysis of the provided table reveals significant positive abnormal returns for key rival firms including Tencent Holdings ADR (OTCMKTS: TCEHY) and Microsoft Corp. Tencent Holdings ADR, in particular, displays an abnormal return of 9.4% following the announcement of the merger.

The gaming industry, renowned for its global influence, poses challenges to policymakers when considering mergers precisely because of difficulties faced in delineating firms' geographical boundaries. In the data above, both the merging firms and rivals exhibit positive abnormal profits. This pattern is suggestive of a collusive-based synergistic merger wherein both the merging companies and their rivals realized positive gains. Although my results are not statistically significant, the FTC's move to implement certain regulatory hurdles does indicate that merger may have contributed to concerns regarding its consequences for competition.

VII. Conclusion

The findings here offer valuable insights into the relationship between stock prices and market reactions following merger announcements and are illustrative of a valuable avenue for exploring various synergies that can be associated with mergers. A greater understanding of the nature of these is vital for understanding strategic implications across the market. While traditional approaches to gauging anti-competitive effects often hinge on complex evaluations of product and geographical markets, the process is often resource intensive. In contrast, leveraging event study analyses similar to that which was done here is a straightforward approach that can be used to evaluate potential repercussions arising from mergers. The simplicity of this approach

makes it an incredibly accessible tool for understanding the implications of mergers across industries. Furthermore, its applicability extends beyond the immediate post-merger period, making it a valuable instrument for conducting retrospective merger analyses.

The current study focused on a limited number of firms within each industry. Future research would benefit from the use of an expanded dataset including a larger and more diverse collection of firms. Additionally, the findings could be made more robust by an expansion of the industries considered with the inclusion of additional sectors to gain a more comprehensive understanding of the effects of horizontal mergers. There also exists a great potential for a more targeted exploration of mergers, looking specifically at both those that are challenged and those that go unchallenged. Such a study may provide important insights that reaffirm the benefits of regulatory scrutiny toward mergers. This analysis would also contribute to a greater understanding of the ways in which stock price behaviors differ between challenged and unchallenged mergers, if at all. Moreover, an expansion of the work here might consider alternative financial models beyond the Capital Asset Pricing Model (CAPM). This might include those like the *Fama and French Three Factor Model* or *Arbitrage Pricing Theory (APT)*. This would provide a useful assessment of the factors that influence abnormal returns beyond a consideration strictly of various firm types. Likewise, future areas of research may explore differences between trends associated with horizontal and vertical mergers. Such research stands to offer a better understanding of the constantly evolving dynamics across the M&A landscape.

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EXPLORE THE EFFECT OF FEMALE LABOR FORCE PARTICIPATION ON BUSINESS STARTUP COSTS

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We examine the impact of female labor force participation on the cost of business startups that are owned by women, employing a panel dataset from nations worldwide spanning from 1960 to 2019. Through fixed effect log-linear regression analysis, we assess whether females entering the labor force translates to a reduction in business startup costs for women. Our model accounts for 9.9% of the variance in the cost of business startup procedures for women, controlling for population density and education attainment, underlining the importance of female participation in the labor force as a determinant of entrepreneurial cost barriers.

I. Introduction

To better understand the optimal policy towards gender disparity in the labor market and business, this research investigates the relationship between the Labor Force Participation Rate (*FLFP*) among females (percentage of the female population ages 15+), modeled by the International Labour Organization (ILO), and the cost of business start-up procedures for females, specifically women-owned businesses and their start-up costs measured in constant 2017 international purchasing power parity (PPP) dollars (*Cost*). We try to show that an increase in the *FLFP* will translate into a percentage decrease in the cost of business start-up procedures for women. At this stage, we expect *Cost* to have a negative relationship with *FLFP*. This expectation is grounded in the rationale that a higher *FLFP*, indicative of a robust culture of women in the workforce, enhances career continuity and autonomy, enabling career planning without interruptions from gender norms. By reducing the opportunity costs traditionally linked with female gender roles, these women are more inclined to redirect their time towards professional endeavors, potentially leading to an upsurge in female-driven businesses. Such a rise in the number of female-driven businesses will reduce women's entrepreneurial cost barrier by economies of scope. The analysis here reveals that for every one percentage point increase in the *FLFP,* there is an associated 4.34% decrease in the *Cost,* after controlling for population density and educational attainment. This outcome underscores the significant impact of female labor force engagement on entrepreneurial affordability and accessibility.

II. Literature Review

Recent research sheds new light on the dynamics of female labor force participation and its broader economic implications. Some explored the "Grand Gender Convergence" in labor markets, discovering that the significant slowdown in employment growth during economic recoveries in recent decades can largely be attributed to the deceleration in women's labor force growth (Fukui et al. 2023). As women's employment rates converged towards men's, there were notable effects on the demand for market goods and services, suggesting interactions between female labor force participation and economic variables, such as entrepreneurship (Fukui et al. 2023). However, their work does not explicitly examine the direct impact of this labor force participation on female entrepreneurship.

Significant contributions to the increase in female labor force participation throughout the 20th century, particularly in developed countries, were driven by married women (Heckman et al. 1986). This increase has been linked to improved maternal health conditions and declining fertility rates, which have historically enabled women's greater participation in the labor force (Goldin et al. 2002). Policy support, especially in the form of childcare and family benefits, has a positive influence on women's workforce participation. For example, childcare subsidies significantly increased labor force participation among mothers (Lefebvre et al. 1997). Moreover, the advent of labor-saving consumer durables has also played a role in reducing the time women spend on household chores, further facilitating their entry into the labor market (Greenwood et al. 2005). Despite these advances, structural and legal barriers continue to limit women's labor force participation in many countries. Such restrictions impact their employment choices and opportunities, underscoring the need for ongoing efforts to address these challenges.

III. Data Description

Table 1- Variable Description

$Cost$	Cost of business start-up procedures, PPP, female (constant 2017 international $)
$FLPR$	Labor force participation rate, female (% of the female population ages 15+) (modeled by ILO)
Ed	Educational attainment, at least Bachelor's or equivalent, population 25+, female
$Fertility$	Fertility rate, total (births per woman)
$Population$	Population density (people per sq. km of land area)
$Trade$	Trade (% of GDP)

Table 2 - Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
FLPR	7550	49.309	14.929	5.922	90.466
Cost	2926	2713.535	3256.248	0	61635.547
Ed	508	17.95	10.653	0	60.981
Fertility	15521	3.923	1.962	.772	8.864
Population	14535	298.839	1516.148	.099	21594.8
Trade	10858	72.109	51.31	.021	863.195

Note: Source: Gender Statistics & World Development Indicators, World Bank Databank. To construct the dependent variable, *Cost*, we employ a computational approach. This process begins with the Gross National Income (GNI) adjusted for purchasing power parity (PPP) in constant 2017 international dollars. We then multiply this figure by the percentage cost of business start-up procedures for females (as a percentage of GNI per capita). The resulting product is then divided by the total national population to normalize the data across different nation sizes. To facilitate a coherent unit of analysis, we adjust the percentage-based result into a dollar value by multiplying it by a factor of 0.01. This conversion ensures that our dependent variable, Cost, is represented in a uniform dollar unit.

This research paper employs panel data collected at the country level between 1960 and 2019 to examine the potential relationship between the Female Labor Participation Rate (FLFP) and the cost of business start-up procedures for females. A total of 297 observations and data from 263 countries have been gathered for each variable between 1960 and 2019.

Control variable data is also gathered from the World Bank but from separate databases. *Cost*, *FLFP*, *Ed*, and *Fertility* are all extracted from Gender Statistics databases, which cover subjects related to demographics, education, and the labor force. Variables such as *Population* and *Trade* are obtained through the World Development Indicators databases. Data themes

include poverty and inequality, people, environment, economy, states and markets, and global links.

The diversity of these variables not only underscores the variability of these indicators across different nations but also highlights the multifaceted nature of economic development as it intersects with gender. Each variable contributes to a richer understanding of the socioeconomic landscape faced by women and provides a foundation for gender-focused economic policies.

IV. Empirical Model

4.1 Regression Model and Theoretical Justification

We employ a fixed effect log-linear regression model within a clustered panel data framework, operationalized through an ordinary least squares (OLS) strategy. The model to be estimated is articulated as follows:

$$\boldsymbol{log(Cost_{it}) = \beta_0 + \beta_1 \times FLPR_{it} + \beta_2 \times Ed_{it} + \beta_3 \times Population_{it} + \alpha_t + \gamma_i + \epsilon_{it},}$$

where $\boldsymbol{Log(Cost_{it})}$ represents the natural logarithm of the cost associated with business start-up procedures for a given entity i at time t. The model includes $\boldsymbol{FL}FP_{it}$ as an explanatory variable, along with $\boldsymbol{Ed_{it}}$ and $\boldsymbol{Population_{it}}$ representing the other clustered control variables, time-fixed effects α_t, country-fixed effects γ_i, and ϵ_{it} is an error term.

We expect the sign of the coefficient β_1 associated with $\boldsymbol{FL}FP_{it}$ to be negative. This expectation is founded on the economies of scope theory of growing women-driven businesses under the framework of a supportive working women culture (as mentioned above in the introduction, we believe that $FLFP_{it}$ is a good proxy of such culture). This trend is indicative of a broader shift where higher female workforce participation is anticipated to lower the financial barriers to initiating business ventures.

4.2 Variable Selection Rationale

FLFP is a continuous explanatory variable of interest. It has been included in the model due to its statistical significance at the almost 10% level and joint significance at the 5% level, implying a noteworthy impact on the dependent variable. *Ed,* a continuous variable measuring female educational attainment, is included in the model for two reasons. First, although *Ed* does not achieve statistical significance individually, it passes the joint test at the 5% level. Second, excluding *Ed* from the model will contribute to an approximately 4.105 standard error of positive bias on the coefficient of the interested explanatory variable. The variable *Population*, a continuous explanatory variable for control, is included in the model. Its inclusion is justified by its statistical significance at the 5% level. Notably, it has been observed to cause approximately a 3.61 standard error positive bias in the coefficient for *FLFP,* an impact substantial enough to warrant its inclusion. Lastly, *Fertility, Trade*, and the interaction term between *FLFP* and *Ed*, are excluded from the model due to its statistical insignificance both individually and jointly.

We explore the potential nonlinearity in the relationship between the dependent variable, *Cost*, and the explanatory variable, *FLFP*. Our initial step involves examining a quadratic relationship by regressing *Cost* on $FLFP^2$. However, the coefficient associated with the quadratic term is not statistically significant, leading us to discard the possibility of a quadratic relationship

between *Cost* and *FLFP.* To determine the most effective form of *FLFP* in explaining variations in *Cost*, we compare the adjusted R-squared values from two models: *Cost* regressed on *FLFP* and *Cost* regressed on log(*FLFP*). Our analysis reveals that the adjusted R-squared of the '*Cost* on *FLFP*' model is higher. This finding suggests that the untransformed *FLFP* explains a larger variance in *Cost* than its logarithmic counterpart. Further, we compare the adjusted R-squared values obtained from regressing log(*Cost*) on *FLFP* and log(*Cost*) on log(*FLFP*). Although both models produce approximately similar adjusted R-squared values, we select the log(*Cost*) on the *FLFP* model for its superior interpretability and real-world economic relevance. Finally, we establish that the R-squared value for the log(*Cost*) on *the FLFP* model is significantly higher at 0.91699776 compared to the adjusted R-squared of 0.0252 from the linear regression of *Cost* on *FLFP*. This stark contrast in R-squared values justifies the selection of the log-linear model (log(*Cost*) on *FLFP*) as the most appropriate for this analysis.

In conclusion, we determine that the log-linear model is the most suitable through econometric testing including polynomial regression, comparing linear versus logarithmic models, and careful consideration of model interpretability and statistical significance. We expect this model to accurately capture the relationship between *Cost* and *FLFP* and provide economically meaningful insights.

V. Results

Figure 1- Time Series Cost in Eastern and Southern Africa, 2002-2019

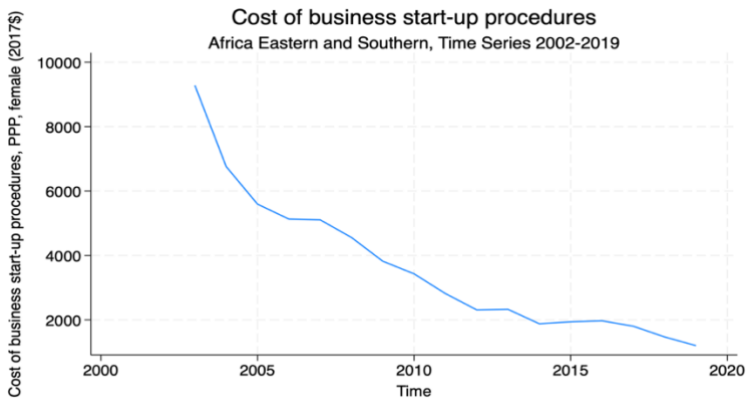

Figure 1 illustrates a significant reduction in *Cost* over 17 years, presented through a downward trajectory. The graph shows a sharp decline in costs until 2008, followed by a more gradual decrease. This pattern suggests that it has progressively become less expensive for women to start a business in these regions, although the rate of decrease has slowed over time.

In *Figure 2*, the negative slope (coefficient of -0.0102) of the line suggests that higher *FLFP* is associated with lower *Cost* in 2010. However, the spread of data points indicates considerable variability, implying that other factors are also at play in determining these costs. This variability signifies that while a general trend exists, the specific situation in each country could significantly influence the *Cost*. Hence, we apply a panel data analysis in *Table 3* to establish the causality between *FLFP* and *Cost*.

Figure 2- Cross-Sectional Linear Prediction of FLFP on log(Cost), 2010

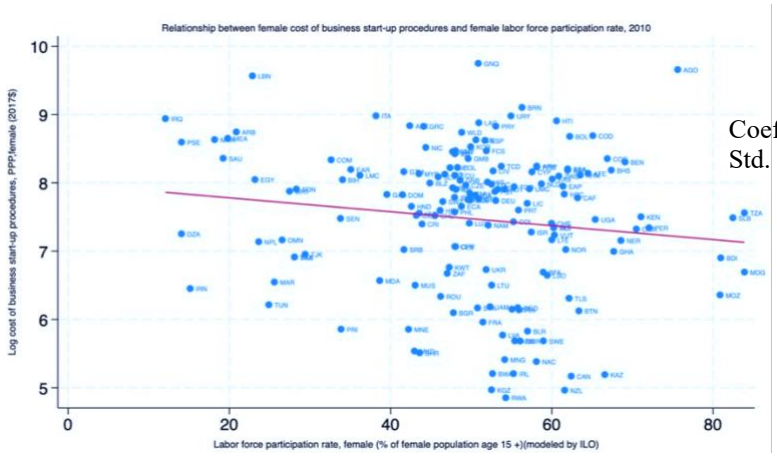

Table 3—Estimates of Working Females: Effect on Change in Start-up Costs Across Countries

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	logcost	logcost	logcost	logcost	logcost	logcost
FLFP	-0.0108***	-0.00670	-0.00503	0.0387*	-0.0446*	-0.0434[2]
	(0.00147)	(0.00445)	(0.00477)	(0.0215)	(0.0263)	(0.0269)
Ed		0.00102	0.00199		0.0261	-0.00333
		(0.00705)	(0.00824)		(0.0188)	(0.00352)
Population			0.000339	-0.00730**		-0.0123**
			(0.000399)	(0.00337)		(0.00487)
Fertility			-0.0144			
			(0.0781)			
Trade			-0.00292			
			(0.00213)			
FLFP × Ed					-0.000586	
					(0.000375)	
Constant	7.917***	7.438***	7.548***	6.368***	9.436***	10.85***
	(0.0732)	(0.269)	(0.367)	(1.020)	(1.330)	(1.471)
Observations	297	297	291	297	297	297
Adjusted R-squared	0.017	-0.000	-0.002	0.058	0.050	0.099
Country FE	NO	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	NO	YES	YES
Number of Country				211	143	143

Notes: The dependent variable is the logarithm cost of business start-up procedures for females, measured in constant 2017 international purchasing power parity (PPP) dollars. The main explanatory variable is the Labor Force Participation Rate (*FLFP*) among females (% of the female population ages 15+) over the same period. Robust standard errors are in parentheses.*** p<0.01, ** p<0.05, * p<0.1

The regressions presented in *Table 3* compare different models to examine the relationship between *FLFP* and log(*Cost*) under possible control conditions. The control factors considered include *Ed*, an interaction term between *FLFP* and *Ed, Population*, *Fertility,* and

Trade. Across all models, the constant term is highly significant, suggesting a baseline log(*Cost*) when all other factors are at zero. Starting with the linear regression (Model 1), the coefficient on *FLFP* is statistically significant at the 1% level, indicating a robust negative relationship between *FLFP* and the log(*Cost*). This aligns with the hypothesis that higher female labor force participation could reduce the barriers to entry for women in business, potentially due to a more supportive business environment for female entrepreneurs. As we move to models that include interactions and fixed effects (Models 2-6), the coefficients of certain variables such as *Ed* and *Trade* display varying levels of significance, which could be partially attributed to multicollinearity. Multicollinearity occurs when independent variables are highly correlated, potentially inflating the variance of the estimated coefficients and making it difficult to isolate the individual effect of each variable. Model 4 introduces the *Population* variable with a fixed country effect, which has a statistically significant negative coefficient (-0.0073) at the 5% level, indicating that a denser population is associated with lower log(*Cost*). This could reflect economies of scope or greater business opportunities in more populated areas. This model also shows a positive coefficient for *FLFP* (0.0387) at the 10% level. This inconsistency with previous results and expectations can be partially attributed to the lack of time-fixed panel analysis of data. In Model 5, the *FLFP* variable is negative and significant at the 10% level (-0.0446), while *Ed* (0.0261) and the interaction term $FLFP \times Ed$ (-0.000586) remain non-significant individually and jointly. Model 6, which incorporates both country-by-year fixed effects, is considered superior for several reasons, despite the p-value for *FLFP* being 0.109, just above the commonly accepted 10% significance level. The higher R-squared value in Model 6 suggests a better fit, explaining more variance in start-up costs than other models. The joint test resulting in a Prob > F of 0.0232 further indicates that the model's variables collectively provide significant economic explanatory power.

The results across these models are consistent with the hypothesis that socio-economic factors such as labor force participation (*FLFP*), and educational attainment (*Ed*), influence the cost of business start-ups for females. In terms of policy implications, a negative coefficient for *FLFP* in the fixed effects model suggests that policies aimed at increasing female labor force participation may effectively lower log(*Cost*). A good example can be government-driven childcare support (Lefebvre and Merrigan 1997). With such a policy, women are liberated from the pressure of traditional gender roles to constantly caretake. Thus, they are more likely to enter the labor market and develop their professional path. Even though the interaction term (*FLFP x Ed*) is not statistically significant, the significant joint test result suggests that increasing labor force participation and educational attainment at the same time among women can be an effective strategy for economic empowerment and business development.

In summary, the reader should note the consistent negative relationship between *FLFP* and log(*Cost*), the potential impact of multicollinearity on the significance of some coefficients, and the importance of considering country and time-specific effects when analyzing cross-country data. Model 6, with its higher R-squared and significant joint F-test result, provides the most comprehensive understanding of the factors affecting female business start-up costs. The *Population* variable is particularly important as it significantly contributes to explaining the dependent variable. Normally, a highly populated area has the benefit of relatively accessible resources like technology, skilled labor, business networks, and others. All such resources would contribute to relatively reducing the female cost barrier related to starting and running a business. The significant and consistent negative relationship between *FLFP* and Log(*Cost*) for females suggests that as more women engage in the workforce, the barriers or costs to starting a business

decrease. However, the models generally explain a very small proportion of the variance in log(*Cost*) (as indicated by the low adjusted R-squared values), implying that there may be other unaccounted factors that influence log(*Cost*). The lack of significance for the *Ed* variable and its interaction with *FLFP* in all models suggests that these factors do not have a strong linear relationship with the log(*Cost*) in this analysis, or that their effects may be captured by other variables not included in the model.

VI. Conclusion

We find that *FLFP* is inversely related to *Cost*. Employing a fixed effect log-linear regression model on a global panel dataset from 1960 to 2019, we find that a one percentage point increase in the *FLFP* translates into a 4.34% decrease in the expected log(*Cost*), while holding *Ed* and *Population* constant. While our model accounts for a modest 9.9% of the variance in *Cost*, highlighting the role of female economic engagement, it also suggests the presence of other influential factors not captured in our study.

The findings have significant policy implications. Encouraging women to participate in the labor force appears to not only empower women but also lower the barriers to entrepreneurship. Policies focused on supporting women in the workforce through childcare support (Lefebvre and Merrigan 1997) can be instrumental in reducing the cost of entering the labor market and the complexity of business start-ups for women. Future policy design should consider these dynamics to foster an environment where women's labor force participation and entrepreneurial endeavors mutually reinforce each other, driving toward a more inclusive and robust economy.

VII. Limitations and Further Research

One key limitation is the potential for omitted variable bias, as the regression model may not account for all relevant variables. For instance, institutional quality could influence both *FLFP* and *Cost*. Strong institutions might promote female employment through better job security and encourage entrepreneurship through equitable legislation. Consequently, not accounting for institutional quality could lead to an overestimation of the effect of *FLFP* on *Cost*. Also, it is crucial to note the limitation due to the smaller sample size. Before finalizing the decision, it would be advisable to explore why there is such a drastic reduction in observations and ensure that the models are not overfitting due to this smaller subset of data.

Reverse causality is another concern, where lower *Cost* leads to higher *FLFP* by creating more jobs and female employment, rather than the other way around. This points to the necessity of establishing causality, which could be better achieved through identification strategies like difference-in-differences (DD) analysis, as discussed in EC365 with Professor James J. Feigenbaum. A DD approach would require identifying a treatment group affected by a policy change or historical event that influences female employment and a control group that remains unaffected.

Future research could improve the current study by incorporating additional control variables such as institution quality to mitigate omitted variable bias. Furthermore, employing a DD strategy could offer a better framework for determining causality. Identifying appropriate treatment and control groups would be crucial in this effort.

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FROM BOOM TO BUST: EXAMINING RACIAL DISPARITIES IN UNEMPLOYMENT DURATION ACROSS ECONOMIC UPS AND DOWNS

Cassondra Stuger, Janelle Williams, and Andrew Smith

The unemployment rate in the United States was 3.7% reported in November 2023. Black citizens experienced a rate of 5.8% and White citizens a rate of 3.3%. The disparities among the racial groups can largely be attributed to structural racism. To further explore the unemployment disparities, during the recession of 2007-2009 the unemployment rate for Black citizens reported 9.5% and 8.8% for White citizens. This reveals an even larger increase in the disparities previously examined. This paper seeks to investigate race's impact on the unemployment duration across economic fluctuations. Utilizing cross-sectional data from IPUMS-CPS, we analyzed data from 2007 to 2022. Our regression models reveal that Black citizens experience an average of 5.175 weeks longer of continuous unemployment compared to White citizens. Additionally, we incorporated variables such as gender, age, educational attainment, regional differences, and interaction terms to gain further insights.

I. Introduction

A recession is defined as a period in which the economy significantly declines in economic activity, exhibiting a negative GDP growth typically for more than two successive quarters (Franke, 2023). Recessions impact economic output, consumer supply and demand, and unemployment rates. In this paper, we specifically focus on the impact they have on unemployment duration for the two racial groups. Recessions are not a rare occurrence within the economy, recording about 33 before the COVID-19 pandemic. The two most recent and notable recessions are, The Great Recession of 2007-2009, and the recession sparked by the COVID-19 pandemic in 2020. Most economic areas stabilized post-pandemic except for the unemployment rate, with 7.1 million fewer Americans documented to be working in July of 2021 in comparison to before the lockdown, in February 2020 (Cox, 2021). To zone in on the Black community, they have historically seen higher rates of unemployment in comparison to other racial groups; the 2020 recession heightened this inequality, with a 10% percentage-point change in the unemployment rate for Black people (Gezici & Ozay, 2020). Recessions pave the way for pre-existing racial structural disparities to be even more pronounced for the Black community.

Our motivation for this research stems from a growing need to specialize research in underrepresented communities. The Black community faces racial disparities in almost every economic and social structure within America. When an event as drastic as a recession hits, the Black community is sent into even more turmoil and feels the effect of such an event significantly more than other communities. The first step is to examine how significant the impact is for the Black community in comparison to a control group, the White community.

In this paper, we will study the effect of race to see how much it impacts the duration of unemployment, with a focus on the years in which a recession occurred to assess how significant the disparity is. The major findings of our analysis show that there is an increase in continuous weeks unemployed for Black individuals of 5.175, compared to White individuals. This potentially can be attributed to America's history of racial discrimination more specifically within the labor market for the Black community. Going further to gain more insight we added additional variables such as age, educational attainment, and regional differences to assess which groups within the Black community feel such disparities the most. We also included some interaction terms to further conclude our results.

Our paper is sectioned off following section 1, the *Introduction*. Section 2 will consist of our *Literature Review(s)*. Section 3 will consist of our *Data and Descriptive Statistics.* Section 4 will consist of our *Econometric Model(s)*. Section 5 will consist of our *Estimation Results.* Lastly, section 6 will consist of our *Conclusion*.

II. Literature Review

We took a step back to examine similar studies to help expand our research on how race impacts the duration of unemployment during an impactful economic event. The reviews introduced other variables that influence the duration of unemployment in culmination with race, such as gender, ethnicity, class, etc. They also introduced topics such as the business cycle and the riskiness and feasibility of exiting/entering unemployment. Overall, these two reviews provide a holistic view of race and unemployment while specializing in different

factors.

Gezici and Ozay (2020) analyze the relationship between racialization and gender during COVID-19, and how they impact the likelihood of unemployment, using microdata from CPS April 2020. It concluded that minority women were disproportionately impacted by COVID-19 in terms of the likelihood of unemployment. More specifically, Hispanic women and Black women were 5.3% and 4.4% respectively more likely to be unemployed compared to White men. The study explored the intersectionality of being a woman and a minority which made it unique from other studies previously done. This allows us to further explore the systematic pre-existing disparities in the labor market for women of color. Our study is similar in exploring the impact of race and unemployment during the pandemic. We would expect to see similar trends in our multiple regression model once we add in gender as a variable. Where we differ is we are taking a step back to look at it from the duration in which the racial group was unemployed.

Couch and Fairlie (2010) examine whether Black citizens are hired last during periods of economic growth and fired first during periods of economic recession. The study uses current Population Survey monthly panel data on Black and White males in the years 1989-2004. The study shows evidence in favor of Black citizens being fired first as the business cycle weakens. The study demonstrates that Black men are 1.2 percentage points more likely to lose their jobs than White men. They also conclude that White citizens' education attainment is continuously higher than Black citizens. This leaves Black citizens more vulnerable to the business cycle during recessions. In our paper, we will also be looking for similar trends, but more recent ones. To further expand upon this study, we will include both males and females of both races. This could potentially explain the variations in our analysis compared to that.

III. Data and Descriptive Statistics

Our paper examines the impact of race on the duration of unemployment, specifically focusing on the significance of the disparity between the unemployment duration among Black citizens compared to White citizens during economic fluctuations. We used repeated cross-sectional data from the IPUMS Current Population Survey database, which is collected between the years 2007-2009, 2018-2020, and 2022. We wanted to capture the Great Recession (2007-2009) and the COVID-19 pandemic (2019-2020). We analyzed 2018 and 2022 as control years where the economy experienced growth, to accurately capture the differences in unemployment.

The independent variable race was cleaned to create a dummy variable for an isolated comparison of Black and White citizens. The dummy variable *Black* was generated by coding all entries of Black = 1 if race == 200 (Black), and Black = 0 if race = 100 (White) * We excluded all other racial categories. The dependent variable, continuous weeks of unemployment (durunemp), was cleaned to eliminate any data entries missing or "Not In-Universe".

To control for endogeneity, we included additional variables such as sex, age, education, and region. Age entries below 15 and above 65 were dropped, assuming individuals outside this range are less likely to be impacted by unemployment. The variable sex was turned into a dummy variable female, with female coded as 1. In our sample, educational attainment, with the variable name educ (education) was revised into the dummy variable *colgrad*, to observe the potential impact of having more or less than 16 years of education on the dataset. Lastly, we created three dummy variables to capture each region – *south, west, and midwest.*

The average person in our entire sample is male, White, 35.97 years old, not a college graduate, and has been unemployed for a continuous duration of 19.46 weeks (Table 2). For the Black

individuals in our sample, the average duration of continuous weeks of unemployment is 23.79 weeks. For White individuals, the average duration of unemployment is 18.62 weeks.

IV. Econometric Model

Simple Regression Models

(1) $\mathbf{durunemp = \beta 1 + \beta 2 Black + e}$
(2) $\mathbf{ldurunemp = \beta 1 + \beta 2 Black + e}$

Econometric model (1) illustrates the relationship between Black and White individuals (*Black)* and the duration of unemployment (*durunemp)*. Model (1) is a simple linear regression model. The variable *durunemp* is the dependent variable and *Black* is the independent variable. *Black* is a dummy variable measuring whether an individual is Black or White. β1 is the constant, β2 is the coefficient of *Black*, and e is the error.
Econometric model (2) is a simple log-linear regression model. The dependent variable is the natural log of *durunemp*, ldurunemp = log(durunemp). The rest of the variables remain consistent with model (1)

Multiple Regression Models

(3)

$$\mathbf{durunemp = \beta 1 + \beta 2 Black + \beta 3 age + \beta 4 female + \beta 5 colgrad + \beta 6 midwest + \beta 7 south + \beta 8 west + \beta 9 y_{2009} + \beta 10 y_{2018} + \beta 11 y_{2020} + \beta 12 y_{2022} + e}$$

(4)

$$\mathbf{durunemp = \beta 1 + \beta 2 Black + \beta 3 lage + \beta 4 female + \beta 5 colgrad + \beta 6 midwest + \beta 7 south\, \beta 8 west + \beta 9 y_{2009} + \beta 10 y_{2018} + \beta 11 y_{2020} + \beta 12 y\_2022 + e}$$

Models (3) and (4) represent the multiple regression models to account for the omitted variables to help control for endogeneity. Model (4) is a multiple regression log-linear model using the logarithm of age.

Interaction between Black and female

(5)

$$\mathbf{durunemp = \beta 1 + \beta 2 Black + \beta 3 age + \beta 4 female + \beta 5 colgrad + \beta 6 midwest + \beta 7 south + \beta 8 west + \beta 9 y\_2009 + \beta 10 y\_2018 + \beta 11 y\_2020 + \beta 12 y\_2022 + \beta 13 Black\_female + e}$$

In Model (5) an interaction term *Black_female* was created by multiplying *female* and *Black.*

The introduction of this interaction term illustrates the effect on the duration of unemployment when an individual is a Black female.

Interaction between Black and colgrad

(6)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest} + \beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y\_2009} + \beta 10\mathbf{y\_2018} + \beta 11\mathbf{y\_2020} + \beta 12\mathbf{y\_2022} + \beta 13\mathbf{Black\_colgrad} + \mathbf{e}$$

In Model (6) an interaction term *Black_colgrad* was created by multiplying *colgrad* and *Black.* The introduction of this interaction term illustrates the effect on the duration of unemployment depending on whether an individual is a college graduate and Black.

Interaction between Black and time

(7)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest} + \beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y}_{2009} + \beta 10\mathbf{y}_{2018} + \beta 11\mathbf{y}_{2020} + \beta 12\mathbf{y}_{2022} + \beta 13\mathbf{Black\_y\_2009} + \mathbf{e}$$

(8)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest} + \beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y}_{2009} + \beta 10\mathbf{y}_{2018} + \beta 11\mathbf{y}_{2020} + \beta 12\mathbf{y}_{2022} \beta 13\mathbf{Black\_y\_2018} + \mathbf{e}$$

(9)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest} + \beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y}_{2009} + \beta 10\mathbf{y}_{2018} + \beta 11\mathbf{y}_{2020} + \beta 12\mathbf{y}_{2022} + \beta 13\mathbf{Black}_{\mathbf{y}_{2020}} + \mathbf{e}$$

(10)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest}$$

$$+\beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y}_{2009} + \beta 10\mathbf{y}_{2018} + \beta 11\mathbf{y}_{2020} + \beta 12\mathbf{y}_{2022}$$

$$+\beta 13\mathbf{Black}_{\mathbf{y}_{2022}} + \mathbf{e}$$

In Models (7-10) interaction terms between *Black* and specific years were introduced to illustrate the effect on the duration of unemployment when an individual is Black in that year.

Interaction between Black, y_2009 and y_2020, and colgrad

(11)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest}$$

$$+ \beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y}_{2009} + \beta 10\mathbf{y}_{2018} + \beta 11\mathbf{y}_{2020} + \beta 12\mathbf{y}_{2022}$$

$$+ \beta 13\mathbf{Black\_y\_2009\_colgrad} + \mathbf{e}$$

(12)

$$\mathbf{durunemp} = \beta 1 + \beta 2\mathbf{Black} + \beta 3\mathbf{age} + \beta 4\mathbf{female} + \beta 5\mathbf{colgrad} + \beta 6\mathbf{midwest} +$$

$$\beta 7\mathbf{south} + \beta 8\mathbf{west} + \beta 9\mathbf{y}_{2009} + \beta 10\mathbf{y}_{2018} + \beta 11\mathbf{y}_{2020} + \beta 12\mathbf{y}_{2022} +$$

$$\beta 13\mathbf{Black\_y\_2020\_colgrad} + \mathbf{e}$$

In Models (11 & 12) an interaction term between Black, the years 2009 and 2020 *Black_y_2009_colgrad* was introduced by multiplying *colgrad*, *y_2009/y_2020* and *Black.* These interaction terms in the multiple regression model help illustrate the effect on the duration of unemployment when an individual is Black in the years 2009 and 2020 with a college degree.

V. Description of Results

Simple Linear Regression Results (Table 4, Model 1 and 2): The simple linear regression model examines the relationship between continuous weeks of unemployment and the dummy variable *Black*. The regression output shows b1 equal to 18.62, demonstrating the predicted continuous weeks of unemployment for White citizens. When Black= 1, durunemp (Table 1) equals 23.79, demonstrating the predicted continuous week of unemployment for Black citizens. b2 equals 5.175, which is the difference in the average duration of continuous weeks of unemployment between Black and White citizens. This demonstrates that on average, Black

citizens were unemployed for over a month longer than White citizens. Our findings align with our hypothesis, that Black citizens experience longer periods of continuous unemployment than White citizens.

We also analyzed a simple log-linear regression model, the dependent variable durunemp was transformed into a natural log (Table 4, Model 2). b_1, has a value of 2.250. When Black = 0, the ldurunemp (Table 1) = 2.250 units representing the duration of unemployment for White citizens is = $e^{2.250}$ or roughly 9.50 weeks. The coefficient of the dummy variable *Black* (b_2 = 0.283), demonstrates that Black citizens experience a 28 percent increase in duration of unemployment compared to their White counterparts (The number of observations in Model 2 is less than the number of observations in Model 1 because all values of 0 for the dependent variable durunemp, meaning 0 weeks of continuous unemployment, are undefined in the natural log)

Multiple Linear Regression Results (Table 4, Model 2 and Model 3): The multiple regression model has additional independent variables to observe their impact on the duration of unemployment among the two racial groups. As demonstrated in Model 2, the average duration of continuous weeks of unemployment varies depending on gender, educational attainment, region, age, and various years. The intercept is 10.04, this demonstrates that an individual who is a White male, with less than 16 years of education, from the Northeast and not surveyed in the years of 2009, 2018, 2020, or 2022 has an average duration of continuous unemployment of about 10 weeks. A Black citizen experiences an increase of about 6 more weeks of average continuous unemployment (b2 = 5.704) than White citizens. Overall, in the data, females have a lower continuous unemployment duration than males (b4 = -0.975) by about one week. Out of the three regions examined in the multiple regression model, it is shown that those in the Midwest average the lowest duration of unemployment (b6 = -2.151) compared to respondents in the South (b7 = 1.338) and in the West. (b8 = -1.438), remains consistent with data reported by the Bureau of Labor Statistics and the Economic Policy Institute as they have stated that the Midwest has the nation's lowest unemployment rate. The impacts of the Great Recession on unemployment can be explained in Model 2, as unemployment for both White and Black citizens increased an additional 5.127 weeks (b9 = 5.127). The average White citizen was unemployed for 15.17 weeks, or about 3.79 months in 2009 compared to the average Black citizen who was unemployed for 20.87 weeks, or 5.21 months in 2009. This demonstrates a staggering difference. In 2018, both Black and White citizens were unemployed for about two weeks longer than the constant (b10 = 1.973), with White citizens unemployed on average for about 12 weeks. Black citizens were unemployed for about 17.5 weeks. In 2020, the two racial groups were unemployed for two weeks less than the constant (b11 = -2.540), which can be possibly attributed to jobs staying steady in the early months of 2020. In the year 2022, both racial groups experienced an additional 2.5 weeks of unemployment, resulting in White citizens being unemployed for an average continuous duration of 12.5 weeks and Black citizens being unemployed for about 18.20 weeks. Out of the four years examined, the trend of Black citizens being unemployed for a longer period than White citizens remains persistent through periods of both economic fluctuations. The largest gap in the continuous duration of unemployment between the two racial groups in our data was in the year 2009. This statistic aligns with predictions that during the Great Recession, Black individuals faced a stark combination of structural inequalities and systemic challenges, furthering the disparities in unemployment

duration. In Model 3, the log-linear multiple regression model provides the result that Black citizens experience 31.6% longer periods of continuous unemployment compared to White citizens (b2 = 0.316). The intercept of this model (b1 = 0.614) demonstrates an individual with a log age of zero, who is a White male, lives in the Northeast, with less than 16 years of education, and was not surveyed in the specific years of 2009, 2018, 2020, or 2022. The b3 value is 0.417, and this demonstrates that a one-year increase in the log age of an individual increases the continuous duration of unemployment by 0.417 weeks, holding all other variables constant. Females in this model experience a shorter duration of unemployment than males (b4 = -0.0581), and college graduates experience a slightly longer period of unemployment (b5 = 0.0154). Consistent with what we analyzed in Model 3, the trend is that citizens in the Midwest average the lowest duration of unemployment (b6 = -0.135) compared to respondents in the South (b7 = -0.0868) and in the West (b8 = -0.0925). The year 2009 again saw the largest increase in total duration of unemployment for both racial groups (b9 = 0.360), with the year 2018 following behind (b10 = 0.0410). The years 2020 and 2022 had lower average unemployment durations when compared to the constant (b11 = - 0.0204, b12 = -0.00722) as well.

Interaction between Black and Gender (Table 5A, Model 4): By adding in an interaction term between Black and the dummy variable *female*, we were able to observe the relationship between the two. In Model 5, the duration of continuous weeks of unemployment for White males is 10.07. For White females, the duration of unemployment is 9.025 weeks. Black males experience 15.564 weeks of unemployment and Black females experience 14.97 weeks. Overall, a similar gap persists as the multiple regression in Model 3, of about 5 weeks between Black citizens and White citizens. The same size gap can be seen between Black and White males and females.

Interaction between Black and Education (Table 5A, Model 5, Table 5B, Models 10 and 11): The interaction of being Black and having a college education in Model 6 lessens the gap in unemployment between Black and White citizens and is one of the few models in our paper to do so. The duration of unemployment for White citizens with less than 16 years of education is 9.99 weeks. For White citizens with a college education, it is 10.16 weeks. For Black citizens with no college education, the average duration of unemployment is 15.89 weeks, and the average duration of unemployment for Black citizens with a college education is 14.49 weeks. An interesting note is that in this model, the duration of unemployment for Black citizens becomes roughly half of a week more (b2 = 5.904) than in the previous Model 5 (b2 = 5.495). This finding is interesting that being a college graduate did not have a larger impact on the duration of unemployment in this dataset, but this could be due to several factors, including that a wide array of industries were affected by both recessions, whether they were minimum wage jobs that can only be secured through extensive education, many citizens of the United States were regardless in similar situations of unemployment or being laid off.

To derive further analysis of this finding, we introduced two new interaction terms: *Black_y_2008_colgrad* and *Black_y_2020_colgrad*, to observe the impact of more than 16 years of education on the duration of unemployment for Black citizens in two specific years of economic recession. Between Black citizens with a college degree and White citizens with a college degree, we observe the smallest difference in duration of unemployment between the two racial groups out of all the models in the sample, 3.54 weeks. Model 13 shows a similar

trend, where Black citizens with a college education experienced 1.537 weeks less unemployment than Black citizens without a college education. Here, we see how educational attainment impacts unemployment duration between the two racial groups. Again, the gap between White citizens and Black citizens is only lessened for Black citizens with a college degree, otherwise, they face roughly the same inequality that has persisted throughout the models.

Interaction between Black and Time (Table 5A, Model 6, Model 7, Model 8, Model 9): We generated time variables to examine the years 2009, 2018, 2020, and 2022. 2009 and 2020 represent years of economic recession in the country due to the 2008 housing crisis that persisted through 2009, and the COVID-19 pandemic that lasted through 2020. 2018 and 2022 represent years where the economy began to or had already recovered from economic decline. In the year 2009, we see the longest duration in unemployment by both racial groups, which signifies how impactful the Great Recession was on the labor market. White citizens were unemployed for about 15.08 weeks on average. Black citizens were unemployed for about 21.31 weeks on average. In the year 2018, White citizens were unemployed for 11.89 weeks on average, whereas Black citizens were unemployed for about 18.28 weeks. In the year 2020, White citizens were unemployed for about 7.70 weeks on average. Black citizens were unemployed for about 12.03 weeks on average. Lastly, in 2022, White citizens were unemployed for about 12.58 weeks, and Black citizens were unemployed for about 17.81 weeks. The largest gap between Black citizens and White citizens was found in the year 2018, which shows how Black citizens continued to be disproportionately unemployed compared to White citizens, even in times of economic growth.

VI. Conclusion

The purpose of this paper is to examine the impact of race on the duration of unemployment more specifically during economic fluctuations (2007-2022) and to further test how significant the disparity is. To take our analysis to the next level we further examined additional variables such as age, gender, region, year, and educational attainment. We also created individual interaction terms between the specific additional variables to isolate their impact on the unemployment duration. To further expand upon the limitations of our study, in the future, we can include the excluded racial groups in our research. This would allow our study to be applied to other minority communities. In the following paragraph(s) we will reiterate the findings that we discussed above while pointing out our most interesting findings.

In the simple linear regression model, we analyzed the relationship between the continuous duration of weeks unemployed between Black citizens and White citizens. Our regression showed that Black citizens averaged 5.175 weeks longer of continuous unemployment when compared to White citizens across our dataset ($b2 = 5.175$). This relationship was also deemed statistically significant through our hypothesis tests.

In the multiple regression model, we expand our analysis to include gender, age, educational attainment, and regions, the basic pattern we observed in the simple regression model remains intact. Additionally, we were able to derive more insight into how the unemployment gap differed over the economic cycles by running regression analysis on isolated years of recession and growth. One of the most important findings in our data is that almost no

endogenous variables significantly *lessened* the gap between Black and White unemployment duration. This is important to note because no endogenous variables were able to result in Black citizens being better off than White citizens, and only one–if a Black individual in 2009 had 16 years or more of education completed (Model 12)–made the gap slightly smaller. Due to this, we believe that the combination of structural inequalities and systemic challenges that the Black community faces in the country is what truly leads to the disproportionate numbers in the sample. Models 12 and 13 were two of our most interesting models because their corresponding interaction terms created the smallest gaps in the duration of unemployment between the two racial groups in the paper. We introduced two new interaction terms: Black_y_2008_colgrad and Black_y_2020_colgrad, to observe the impact of more than 16 years of education on the duration of unemployment for Black citizens in two specific years of economic recession. In Model 12, in the year 2009, Black citizens with a college education were better off than Black citizens without a college education, experiencing 2.241 fewer weeks of continuous unemployment. Between Black citizens with a college degree and White citizens with a college degree, we observed the smallest difference in duration of unemployment between the two racial groups out of all the models in the sample, 3.54 weeks. The gap between White citizens and Black citizens was only lessened for Black citizens with a college degree, otherwise, they face roughly the same inequality that has persisted throughout the models, which is a very similar finding to Couch and Fairlie (2010), therefore we can derive similar conclusions on the role that educational attainment inequality plays in the disproportion of unemployment between the two groups.

What makes our research unique is our focus on the unemployment duration rather than the unemployment rate. By analyzing the duration this allows us to see how long the various racial groups must withstand unemployment. This opens the potential for our research to be applied to other economic factors that contribute to the inequalities faced by the Black community. More specifically our research can be applied to economic policy creation with a focus on advancing the Black community's economic success. This can help policymakers to identify and target the right individuals within the Black community who experience the longest duration of unemployment based on age, gender, region, and educational attainment.

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HOUSING AND EMPLOYMENT BEHAVIOR: THE RELATIONSHIP BETWEEN PUBLIC HOUSING RESIDENCE AND WEEKLY HOURS WORKED

Tsega Wondwossen, Elizabeth Luongo, and Sania Sadarangani

While there are significant benefits of public housing such as a decreased likelihood of housing instability and a shift of family resources from housing to other expenses, there are other reasons that lead people to live in public housing, including unemployment and low availability of affordable housing alternatives. It could be argued that living in public housing is an indicator of these socioeconomic impediments. The need for affordable housing fluctuated as a result of the economic changes experienced during the COVID-19 pandemic. Our research stems from a related question: does residing in public housing correlate with the number of hours worked by the people who live in these communities? What societal factors have contributed to the relationship between these two variables? Our research was conducted to understand the relationship between public housing access and the number of hours worked. Our results show a significant association between our main variables, implying that being a resident of public housing may predict decreased weekly hours worked. In this paper, we use data derived from the Current Population Survey (CPS) from the years 2018 to 2022 which account for the COVID-19 pandemic and its socioeconomic effects. As a result, we found that there was a positive change in the predicted hours worked by members of minority communities, as well as those lacking higher education. It is important to note that much of our research is both similar and different to studies previously conducted.

I.Introduction

The purpose of public housing in the United States is to provide low-income families with safe and decent rental housing, overseen by the U.S. Department of Housing and Urban Development and administered by Public Housing Agencies (PHAs). As of 2021, about 970,000 families occupy public housing (HUD 2021). Eligibility for public housing involves three factors: 1) an annual gross income of less than 80% of the median income in the city or county; 2) whether one qualifies as an elderly person, has a family, or is a person with a disability; and 3) valid citizenship or immigration status. Once an individual applies for public housing, eligibility is determined by Housing Agencies (HUD 2021). However, public housing is not necessarily the safety net that one might expect. This is because public housing is often placed in areas with high rates of poverty and unemployment. Stability in housing alone may not be a sufficient safety net when residents are faced with other effects of poverty and unemployment, such as the lack of basic healthcare and food insecurity. This could lead to poorer health and a lack of income, causing a bleak economic cycle.

Since the start of the COVID-19 pandemic, housing prices have been steadily increasing (Ciurczak 2022). This increase in housing prices has caused many to turn to public housing (Zhang 2021). The government supports low-income renters in two main ways: public housing in government-operated buildings and Section 8 vouchers that allow voucher recipients to rent from any landlord that accepts the vouchers. While our research focuses on residents of public housing, it is important to note the increased need for both programs. Federal funding of public housing projects has increased drastically from $16 million in 2020 to $97 million in 2021, a 479% increase (Ciurczak 2022). In a world where housing prices are extremely high and inflation is increasing, the affordability of all items has declined for the average household. A CNBC article states that "in many major U.S. cities, minimum wage workers need to clock in over 50 hours each week just to be able to afford rent on a one-bedroom home," showing the unaffordability of housing in our current economy (Schiff 2022).

This paper will examine the relationship between public housing residency and the total hours worked by an individual by developing a multiple regression model and using IPUMS-CPS ASEC data from 2018 to 2022. This paper finds evidence that residing in public housing is a predictor of low weekly hours worked, even when controlling for multiple factors such as demographics, health status, and family size. Even with this evidence, we cannot attest that being in public housing results in lower hours as there may be other variables that are not accounted for, suggesting that those in public housing may have other reasons for not working the same level of hours as those not in public housing.

Given the dramatic increase in the need for public housing and the economic effects of the pandemic, our research question originally came about considering how residents in public housing were being affected. That leads us to narrow our question to whether or not being a resident in public housing is an estimator of their total hours worked. The paper will evolve as follows. In **Section II**, we will walk through the major literature review surrounding the factors leading to being in public housing, the characteristics of who is most likely to be in it, and how much time they can devote to their job. Following this, **Section III** will demonstrate the population econometric models that will be used to better estimate the relationship between our main independent and dependent variables, along with an explanation of the theories behind these models and the multiple variables that are included. Next, the data set that is used in the paper and the steps used to clean it are in **Section IV**. The results from the models used and

regression analysis can be found in **Section V.** Lastly, the important findings and possible limitations of this study are in **Section VI.**

II. Literature Review

First, it is important to investigate the prior research on who is in public housing and if a relationship between them and the number of hours these individuals work exists. Yelowitz (2001) provides relevant and interesting findings that serve as a crucial foundation for this paper. He used both the Consumer Population Survey (CPS) and Survey of Income and Program Participation (SIPP) from 1990-1995 to look at the work behavior of female-headed households with children. As his study uses data from CPS, we can assume similar patterns of clustering when examining macroeconomic trends. He finds that within CPS, 23% of the respondents in public housing are enrolled in part-time work and hence are limited to working 35 hours a week compared to 18% of the respondents who are not in public housing. Even more significant, 28% of the respondents in public housing are enrolled in full-time work which is measured by 36+ hours per week annually compared to a striking 62% enrolled in full-time work within the pool of those who are not in public housing. The results are similar when looking at SIPP data, in which 30% of individuals in public housing have a full-time job (40 hours a week), relative to 69% of individuals not in public housing. When looking at the CPS data, only 51% of the public housing residents are employed at any level, compared to 80% of those not in public housing, a substantial difference. Overall, this paper concludes that residing in public housing is a predictor of fewer hours worked without controlling for other variables. Additionally, research by Martinez (2002) explains how within the pool of public housing residents, about 18.3% are employed full-time while 30% have never been employed, which is similar to Yelowitz's findings. Another interesting conclusion by Martinez is that of public housing residents, about 12% know someone within their community who has full-time steady paid work compared to 47% of residents outside the public housing community.

There has been extensive research conducted on the family lifestyles, education attainment, and well-being of those who are in public housing. Notably, research suggests that the education levels, as well as family sizes, signal the demographics of those in public housing. Public housing recipients are twice as likely to be a "high school dropout, and have slightly larger families, on average" (Yelowitz 2001). Yelowitz continues that 20% of female-headed households with children receive government-subsidized housing, implying that as a single mother, there is a 1 in 5 chance they will be in public housing. Additionally, Martinez explains that for each additional child, the likelihood of full-time employment decreases. With one child, 28% of the sample is employed full-time, with two children, 27%, and with three or more children, full-time employment decreases to 23%. Within the sample size of those in public housing, 31% of respondents are high school dropouts, compared to 19% of nonresidents (Yelowitz 2001). Martinez finds that "the less connected to the labor market respondents were, the more likely they were to have less than a high school diploma" (Martinez 2002).

Martinez continues that those in public housing who are employed are more likely to have jobs that are lower-paying and "without fringe benefits," such as health insurance. Moreover, those individuals who had recent full-time employment "had better quality jobs than did those whose recent employment was part-time" (2002). Martinez concludes that for residents of public housing, "health status is a factor that is most clearly associated with individual participation within the labor market" (2002). This is an interesting conclusion as those residing

in public housing are less likely to have health insurance. Additionally, Martinez finds that respondents with "health problems were less likely than others to have had recent work experience or to engage in job search activities" (2002). Martinez finds that 47% of those without recent employment have a health status of fair or poor and "twice the proportion of those recently employed full time, [are] at 26 percent." He expresses that employees with better health are more able to work full time and full-time employment often comes with health insurance which can lead to better health (Martinez 2002).

Carlson (2009) conducted a study using longitudinal data to explore the effects of public housing vouchers on labor market outcomes. The results conclude that the overall receipt of a public housing voucher has a positive effect on employment and a negative effect on earnings, which was found to diminish over time. It is also worth noting that these effects vary depending on demographics. The study found this earnings effect to be positive by the fifth year of the study for urban, young, those without a high school education, and Black workers – with that of Black workers being statistically significant. Lastly, the study states the following:

> "By five years after voucher receipt, any early negative employment effect of voucher participation had decreased, and for some of the most disadvantaged groups, positive significant effects of the program on average quarters worked are observed…traditionally disadvantaged populations—such as racial minorities and poorly educated individuals—respond to housing voucher receipt with behavior that is most consistent with that originally envisioned by policy designers" (Carlson 2009).

The study concludes that government-subsidized public housing improves the economic self-sufficiency of minorities and contributes to labor market success.

Additionally, longitudinal regression analysis done by Weinberg (2004) found a relationship between one's given neighborhood and hours worked. The study aimed to measure the social influence a neighborhood has on its residents regarding labor participation. The study controlled for marital status, mother's education, race, number of own children, and education level. This gives us plausible evidence of a positive correlation between family size and hours worked. In addition, the study confirms that neighborhoods have specific job proximity and employment levels within them that ultimately are correlated with hours worked. Based on regression estimates, the study states that a one standard deviation increase in the employment level of a neighborhood increases annual working hours by 28%, which is extremely statistically significant (Weinberg 2004). In the conclusions of the study, it is evident that there is a strong correlation between the neighborhood one lives in, and their annual hours worked due to social influences, location, and more. Accordingly, it is expected that neighborhoods with public housing density correlate with a high degree of joblessness and a high degree of poverty (Martinez 2002).

In sum, we have found contradictory studies regarding whether residing in public housing has a statistically significant relationship with employment, and whether this relationship is positive or negative. There is little empirical evidence on how the public housing status directly affects work behavior, but rather the research is on neighborhoods affecting employment behavior. A limitation of these literature reviews could also be due to the pandemic. During COVID-19, people with better-paying jobs could often work from home, enjoying comfort and working more. However, those in public housing, typically with lower-paying jobs requiring on-site presence, might not have had this flexibility, possibly leading to shorter work hours or a

change in hours worked. Additionally, as we looked to see the role played by COVID-19, little literature exists regarding how the pandemic affected hours worked, as COVID-19 rates continue to fluctuate. Further limitations of this research which we observed consistently throughout our research was that the sample size of those in public housing is small, which could omit public housing residents with more robust work experience.

Overall, our multiple regression-based analysis was influenced by the prior research conducted in this field, and what little exists of it. The following variables were used to better control for endogeneity in public housing residents to the number of hours worked for individuals: race, sex, health, age, high school graduation or equivalent, and number of children.

III. Econometric Model

Simple Linear Regression Models:

$$(1)\, uhrsworkt = \beta_0 + \beta_1 pubhous + \epsilon$$
$$(2)\, luhrsworkt = \beta_0 + \beta_1 pubhous + \epsilon$$

Table 1-Descriptions of Variables

Variable Name	Variable Description
year	The survey year (2018-2022)
pubhous	Dummy variable where a respondent not living in public housing is indicated by a 1 relative to a respondent living in public housing is a 0
pubhous_rev	Dummy variable with a value of 1 indicates a respondent is in public housing and 0 represents for individuals not in public housing
sex	The sex of the respondent, female or male
race	The race of the respondent, black, white, asian,
nchild	This variable indicates the respondent's number of own children in household, with 1 child to 9 children
uhrsworkt	This variable indicates the hours usually worked per week at all jobs of a respondent
educ	This variable indicates the education of a respondent
health	The variable indicates the respondent's health status, where
age	This variable indicates the age of the

	respondent, 16-85
educ_rev	Educational Attainment Recode where REVISED
hsg	Dummy variable with 1 represents individuals that graduated high school or equivalent and 0 for those who did not
black	Dummy variable with 1 represents individuals race as black and 0 for any other race
female	Dummy variable with 1 represents individuals' sex as female and 0 for male
good_health	Dummy variable with 1 represents individuals as having good health which include excellent, very good, good and a 0 for fair or bad good
covid_year	Dummy variable where a valuable of 1 indicates the survey occurred in 2020, 2021, or 2022 and a 0 for 2018 or 2019
pubhous_rev_female	Interaction term where 1 indicates a respondent lives in public housing and is female
pubhous_rev_black	Interaction term where 1 indicates a respondent lives in public housing and is black
pubhous_rev_hsg	Interaction term where 1 indicates a respondent lives in public housing and is a high school graduate
age_squared	Quadratic variable used to account for non linear patterns in the model, model diminishing hours worked (returns) to age
uhrsworkt_yes	Dummy Variable where 1 indicates a respondent is in public housing and their estimated hours worked
uhrsworkt_no	Dummy Variable where 1 indicates a respondent is not in public housing and their estimated hours worked

To better understand our models and predictions, this paper first needs to establish if there is a relationship between public housing residence and the total hours worked. The simple linear regression models are useful when examining a possible relationship between an individual who is in public housing or not, and their total hours worked. The β_0 in our data is the

population constant. The β_1 in our simple linear regression is our population slope. These population parameters are estimations of our relationship between hours worked and public housing. If the public housing dummy variable includes a significant coefficient, then there appears to be a predicted change in hours worked. Additionally, if the coefficient is negative, then it appears that being in public housing hinders one's ability to work more hours compared to those not in public housing. We expect the result to be negative as we believe being in public housing hurts one's ability to be in full-time work without including other control variables.

Simple Linear Regression Model 1:

This model depicts our simple linear regression model which regresses the *uhrsworkt*, the total hours worked weekly on *pubhous_rev,* the cleaned variable for people who live in public housing.

Simple Log-Linear Regression Model 2:

This model depicts a log-linear functional form of our simple linear-linear regression model. The log-linear equation corrects for the skewness that can be seen in the hours worked distributions. The model will exclude weekly hours worked of 0. However, this model is not significantly better at describing the relationship. In both models, these equations allow for a better estimate of the relationship between the two variables in our data through the two different functional forms.

OLS Assumptions:

To create the simple linear regression models, we first needed to confirm that our variables met the four OLS assumptions. The first OLS assumption is if the sample error, $\hat{e} = 0$ for Model 1 and Model 2. In Figure 1, the $\hat{e}$ (sample error) is equal to $-8.3*10^{-10}$, which is approximately 0, hence our first assumption is met. The second OLS assumption is also approximately met since there is a constant variance, therefore the sample variance is homoscedastic, as seen in Figure 2. Regarding the third OLS assumption, there is a possibility of autocorrelation or clustering as CPS has a cross-sectional gathering of data. It should be noted that CPS collects data from households, which increases the probability of clustering in the data, however, it should not be statistically significant as the sample size is so large. Furthermore, autocorrelation is also possible given the years we are using for our data – the COVID-19 pandemic caused lasting macroeconomic trends affecting everyone in the U.S., as mentioned in the introduction. In the fourth assumption, we can check for a normal distribution by looking at the histogram seen in Graph 2. The sample size is 43,726 observations meaning that it is large enough and the central limit theorem applies so that we can reasonably assume a normal distribution.[24]

[24] Refer to Graph 2

Figure 1 - Showing 1st Assumption

```
. predict ehat, resid
(4 missing values generated)

. sum ehat
```

Variable	Obs	Mean	Std. dev.	Min	Max
ehat	44,815	-8.30e-10	.3348357	-3.639308	.9658622

Figure 2-Hettest

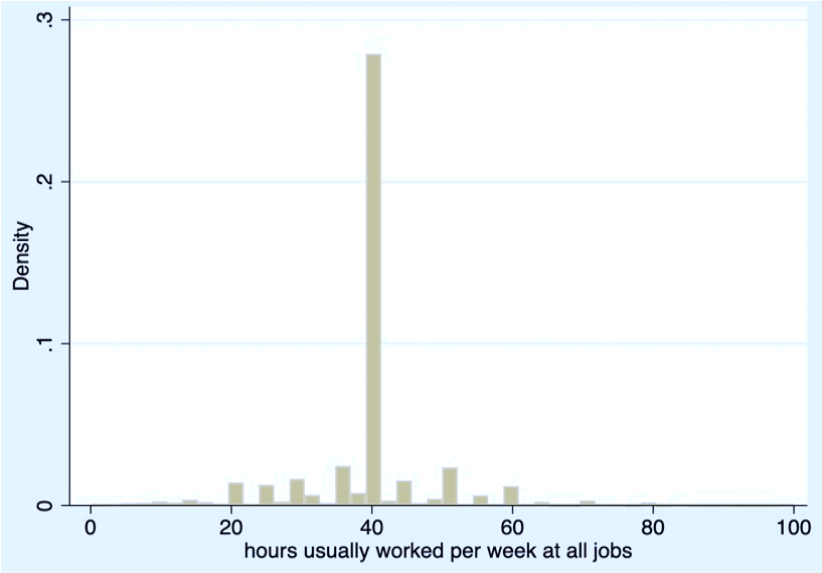
```
. hettest

Breusch-Pagan/Cook-Weisberg test for heteroskeda
Assumption: Normal error terms
Variable: Fitted values of uhrsworkt

H0: Constant variance

    chi2(1) =  50.81
Prob > chi2 = 0.0000
```

Graph 2- Histogram of Hours Worked (Showing Normal Distribution)



Multiple Linear Regression Models:

(3) $uhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + e$

(4) $luhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + e$

Multiple Linear Regression Model: Model 3

In Model 3, the public housing variable is included as well as the total hours worked weekly, similar to the simple linear regression. However, there are 6 additional variables to create the multiple regression model shown in Model 3 and Model 4, which attempt to better control for certain lifestyle differences and demographics that may end up biasing the total hours worked. The first additional variable added is the *good_health* variable, indicating whether an individual has good health. If an individual has good health, we expect that they are more likely to work more hours. The additional *nchild* variable represents the number of children that are present in each household. This variable was added because having more children could lead to an individual working more hours to support their family or less as they are busy tending to children. Additionally, the demographic variables include the sex of the person, which we coded as female, as well as their race, which we coded as a dummy variable for *black*. This was introduced, as typically lower-income Black women are in public housing, as seen in Weinberg's findings, and can lead to taking different and possibly more time-consuming jobs (Weinberg 2004). Furthermore, COVID-19 played an important role for those in public housing and their ability to work, given that it increased the unemployment rate and made individuals stay at home longer (Weinberg 2004). This variable is characterized by the year that each survey was conducted. This study is looking to discover if the pandemic was significant in the prediction of hours worked based on whether one is in public housing or not. The variable *covid_year* uses 2018, 2019 as the base and 2020, 2021, and 2022 when *covid_year* equals 1 as these years have the most COVID cases in the U.S. Additionally, *hsg* is a new variable that we created that conveys individuals who had received their high school diploma or equivalent. Lastly, we add the variable *age* to account for the relationship that various ages have with hours worked. With the switch to a multiple regression model, we can more effectively account for the additional factors that are endogenous to the total weekly hours worked variable.

Multiple Log-Linear Regression: Model 4

The fourth model incorporates the same additional variables but in log-linear form.

Multivariable Regression Models with Interaction Terms:

(5) $uhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + \beta_9 pubhous\_rev\_female + e$

(6) $uhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + \beta_9 pubhous\_rev\_black + e$

(7) $uhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + \beta_9 pubhous\_rev\_hsg + e$

(8) $uhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + \beta_9 age\_squared + e$

(9) $uhrsworkt = \beta_0 + \beta_1 pubhous\_rev + \beta_2 good\_health + \beta_3 nchild + \beta_4 female + \beta_5 covid\_year + \beta_6 black + \beta_7 hsg + \beta_8 age + \beta_9 pubhous\_rev\_female + \beta_{10} pubhous\_rev\_black + \beta_{11} pubhous\_rev\_hsg + e$

Multiple Regression Models with Interaction Terms: Models 5, 6, 7

Three interaction terms are introduced in the multivariable regression models above. Model 5 introduces *pubhous_rev_female*, which is an interaction term between our main independent dummy variable *pubhous_rev* and the dummy variable *female*, allowing us to control for demographics in terms of sex regarding male and female individuals. This will help us explore whether the relationship between being in public housing on hours worked varies by gender. Hence, it will help us determine how many hours worked depending on whether an individual is a female or male in public housing.

Model 6 introduces our second interaction term, *pubhous_rev_black*. This term is an interaction between our main independent dummy variable *pubhous_rev* and the dummy variable *black*, allowing us to control for demographics regarding Black and non-Black individuals. As shown in our literature review, labor market participation and earnings of Black Americans were shown to have a positive correlation with being in public housing after five years (Carlson 2009). This will allow us to explore how much the relationship between being in public housing has on hours worked differs depending on whether an individual is Black or not.

In Model 7, we introduce our third interaction term, *pubhous_rev_hsg*. This is an interaction term between our main independent dummy variable *pubhous_rev* and dummy variable *hsg*, which denotes whether someone has a high school diploma or GED equivalent. This will demonstrate whether the estimated hours worked by those in public housing depend on whether someone has a high school education or not.

Hypothesis Testing:

Table 6-Hypothesis Tests

Tests	P-Val: Model 8 (without interactions)	P-Val: Model 9 (with interactions)
H_0: $\beta_3 = 0$	0.7445	0.744
H_0: $\beta_5 = 0$	0.9765	0.963
H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$ H_1: $H_0 \neq 0$	0.000	n/a
H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$ H_1: $H_0 \neq 0$	n/a	0.000

Hypothesis tests allow us to understand the levels at which our models represent our intended ideas. In these tests we used Model 8, a linear-linear regression model without interaction terms, and Model 9, a multiple regression model with interaction terms. At the 0.01 significance level, our tests will show us if our models are statistically significant when compared to our conjecture of zero.

Test 1: *nchild*

H_0: $\beta_3 \geq 0$

H_1: $\beta_3 < 0$

In our first test, we ensured that the effect of the number of children in a household on the number of hours worked was at least zero. To understand this, we ran the regression on Stata to get the p-value of 0.511 for Model 8 and 0.512 for Model 9. To get the value of the left-tailed test, we subtracted these values from 1 and got 0.7445 [25] for Model 8 and 0.744[26] for Model 9. For both models the p-values are greater than the significance level of 0.01, making us fail to reject the null hypothesis at the 1% level of significance and conclude that the effect of an extra child in a household on the number of hours worked is at least zero in the population, with all other variables controlled.

Test 2: *covid_year*

H_0: $\beta_5 \geq 0$

H_1: $\beta_5 < 0$

Similar to the first test, we completed the same protocol for the effect of the coefficient of *covid_year* if the number of hours worked, *uhrsworkt*, was at least zero. After our calculations for the left-tailed test, our p-value for Model 8 was 0.9765[27] and 0.963[28] for Model 9. In the same way, both models have p-values that are greater than 0.01 and we fail to reject the null hypothesis at the 1% significance level. Hence, we can conclude that the effect of an extra COVID year on the number of hours worked is at least zero in the population, with all other variables controlled.

Test 3: F-test

The F-test is our final test, which we use to assess the overall significance of the models. To do this, we create a null hypothesis that coefficients on all of the explanatory variables equate to zero. Using the F-statistic supplied to us by Stata[29], we compare it to the critical F-value we calculate for Model 8. To get our critical value, we find the number of restrictions and the N-K and found the value 2.41[30] at a 0.01 significance level on the F-table. For Model 9, we followed the same steps and found a value of 2.25[31] at a 0.01 significance level. In both models we see that the F-stat is greater than the critical F-value, hence allowing us to reject the null hypothesis and conclude that at least one of the variables in both models affects *uhrsworkt*.

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[25] nchild_pval_model8 = 1- (0.511/2) = 0.7445

[26] nchild_pval_model9 = 1 - (0.512/2) = 0.744

[27] covid_year_pval_model8 = 1 - (0.047/2) = 0.9765

[28] covid_year_pval_model9 = 1 - (0.037/2) = 0.963

[29] Fstat = 397.53

[30] F_c=(8, 44811) = 2.41

[31] F_c=(11, 44808) = 2.25

IV. Data and Descriptive Statistics

The data that is used in this study is from the IPUMS-CPS. The Annual Social and Economic Supplement (ASEC), and the basic monthly data from CPS provide the data for the IPUMS-CPS. The ASEC for both the main independent and dependent variables is the data that our study is based on. Since 1977, CPS has interviewed households whose members are not buying and do not own their houses, assuming that homeowners are excluded because zero equals the renters of private units. Public housing (*pubhous*) indicates whether an individual's home is a part of a government housing project for people with low incomes, with homeowners excluded from public housing. Households that reported “yes” were receiving housing assistance at the time of the ASEC survey. Public housing is a variable relating to means-tested government assistance. Only households in which the household members' combined income fell below a given level were questioned about means-tested program benefits. Households with estimated incomes above the threshold were presumed to not qualify, and were coded as "no.” A revised form of *pubhous* was created which represents a 0 as a base category if the respondent is not in public housing and a 1 if the respondent is a public housing resident. Our dependent variable (*uhrsworkt*) looks at hours usually worked per week at all jobs. All sample members are civilians at least 15 years old who are employed and were either at work or absent from work during the survey week. This source utilizes repeated cross-sectional data as this is a yearly survey and the likelihood of the same individuals is relatively small given the large sample size.

The IPUMS-CPS recorded the survey results from public housing and self-reported hours worked by respondents from 2018 to 2022. These years were picked because 2018 and 2019 have very limited COVID data as opposed to 2020, 2021, and 2022 and we wanted to see how the pandemic related to those that were in public housing and the relationship with individuals’ total hours of work. The data from the 5 years were pooled to create the sample used in this data. This self-reporting of hours worked includes a degree of reporting error, which could bias our coefficient estimates. To better correct for any errors, those who reported 0 hours worked, hours that vary, and those who are not in the universe such as individuals under the age of 15 or those who are not employed but reported hours were dropped from the sample. Additionally, individuals who are not in the universe of public housing, such as households, were dropped to better estimate. These cleaned values are used for both our main independent and dependent variables throughout the paper. The base category is *pubhous*=0, meaning these individuals are not in public housing. Revised public housing, *pubhous_rev*, is a dummy variable we use as the independent variable, and cleaned hours worked *uhrsworkt* is the dependent variable. There were initially 834,419 observations, and after cleaning, the total was 44,819 observations. Any of the missing values for total hours worked or those in public housing were dropped from the sample.

Another independent variable in the regression analysis is *nchild,* which represents the number of children in the household. We included *nchild* because Martinez found that the total hours worked by respondents in public housing can differ depending on the number of children in the household (2001). The observations for those with no children seemed to have an NIU value so our sample only looks at individuals who have at least one child and dropped if the variable included nine or more children. Additionally, the variable *year* is included to represent the data collected from 2018 to 2022. We generate a new *covid_year* variable to see if COVID-

19 could be an estimator of employment behavior. Additionally, *female*, high school graduate (*hsg*), *black*, health status (*good_health)*, and *age*[32] were included.

Descriptive Statistics (Table 2, Table 3):

Table 2-Summary Statistics of the Variables

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
age	44,819	40.04	10.59	16	85
nchild	44,819	1.911	1.027	1	8
uhrsworkt	44,819	39.51	10.20	0	100
pubhous_rev	44,819	0.0544	0.227	0	1
hsg	44,819	0.851	0.356	0	1
black	44,819	0.173	0.378	0	1
female	44,819	0.541	0.498	0	1
good_health	44,819	0.924	0.264	0	1
covid_year	44,819	0.534	0.499	0	1

Table 3-Summary Statistics of Relevant Variables according to Public Housing Residency

	(1) Not in Public Housing (=0)	(2)	(3) In Public Housing (=1)	(4)	(5)
VARIABLES	N	mean	N	mean	differ
age	42,383	40.16	2,436	37.97	2.19
nchild	42,383	1.904	2,436	2.026	-0.122
uhrsworkt	42,383	39.72	2,436	35.98	3.74
hsg	42,383	0.853	2,436	0.818	0.035
black	42,383	0.164	2,436	0.321	-0.157
female	42,383	0.533	2,436	0.690	-0.157
good_health	42,383	0.926	2,436	0.894	0.032
covid_year	42,383	0.533	2,436	0.554	-0.021

The average person in this sample can be found in Table 2. They are not in public housing, are 40 years old, work 39.5 hours weekly, graduated high school, are female, and have good health. Within the sample size, 5.5% of the sample is in public housing, 85% are a high school graduate, 17% are Black, 54% are female, 92% of the sample size has good health and 53% of the data was collected from 2020, 2021, and 2022.

Table 3 shows the characteristics of their public housing status. The sample size of those not in public housing has 42,383 observations making up the majority of the entire sample size compared to 2,436 individuals who are in public housing. Individuals who are not in public

[32] Refer to Table 1 for variable definitions.

housing work 39.72 hours relative to those who do live in public housing who work an average of 35.98 hours. Additionally, amongst individuals who are not in public housing, only 16% of the sample is Black, compared to 32% of those in public housing. Also, females disproportionately make up the public housing sample with 69% compared to 53%. Additionally, among those not in public housing, 85% have a high school diploma or equivalent compared to 81% of individuals in public housing. Lastly, those in public housing are younger than those not in public housing, with the average individual two years younger than those not in public housing.

V. Description of Results

Simple Linear Regression: Model 1 (Table A)

Table 4A-Linear-Linear Regression Models without Interaction Terms

	(1)	(2)	(3)
VARIABLES	Model 1	Model 3	Model 8
pubhous_rev	-3.734***	-2.883***	-2.804***
	(0.212)	(0.207)	(0.207)
good_health		1.310***	1.280***
		(0.177)	(0.177)
nchild		-0.0290	-0.142***
		(0.0458)	(0.0464)
female		-4.852***	-4.842***
		(0.0949)	(0.0946)
covid_year		-0.196**	-0.211**
		(0.0934)	(0.0932)
black		0.657***	0.670***
		(0.125)	(0.124)
hsg		1.841***	1.799***
		(0.133)	(0.133)
age		0.0342***	0.411***
		(0.00444)	(0.0267)
age_squared			-0.00437***
			(0.000306)
Constant	39.72***	38.20***	30.89***
	(0.0494)	(0.312)	(0.599)
Observations	44,819	44,819	44,819
R-squared	0.007	0.067	0.071

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Model 1 describes a simple linear regression model with a $\beta_0 = 39.71505$.[33] This number is the y-intercept of the model which represents the estimated number of hours worked weekly

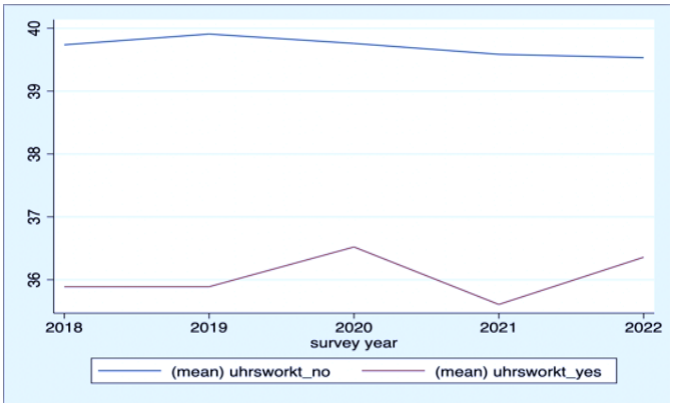
[33] uhrsworkt(hat) = 39.71505 - 3.733524 (*pubhous_rev* = 1) = 35.981526

by an individual who is not in public housing, and thus coded as 0, since *pubhous_rev* is a dummy variable. Furthermore, β_1 is the slope and represents the difference between the estimated hours worked for those in public housing, and those who are not. The value of β_1 for the simple linear regression model is -3.733524, which indicates that relative to those who are not in public housing, individuals who are in public housing work 3.733524 hours less. After plugging in the estimated values of $\beta_0 + \beta_1$, we get the estimated hours worked for an individual in public housing, which is 36.048843 hours.[34] The semi-elasticity is -9.5%[35], and was calculated at the mean hours worked value, shown in the summarize command in Table 2. This semi-elasticity indicates that, on average, individuals who live in public housing hours worked decreased by 9.45%. Table 4 demonstrates the results of Model 1, a simple linear regression of hours worked (*uhrsworkt*) on public housing (*pubhous_rev*), testing for whether being in public housing or not significantly changes predicted hours worked, and whether this association is positive or negative. As seen in the table under Model 1, people in public housing are shown to work 3.734 fewer hours per week relative to those not in public housing. However, it should be noted that this model is not optimal for drawing conclusions, as it doesn't control for omitted variables and other unobserved variables that can lead to endogeneity.

Multiple Linear Regression: Model 3 (Table 4A)

Through the results of Model 3, we can more accurately denote the relationship between public housing and hours worked by controlling for various variables, such as sex, health, COVID year, and age, inspired by our literature review. In Model 3, we observe the change in predicted hours worked for those in public housing to be lower than those who do not, as the coefficient indicates that being in public housing estimates hours worked to be 2.883 hours less per week, holding all other variables constant. Furthermore, when incorporating control variables, we can observe the estimated hours worked to be 1.31 more hours if an individual has good health, relative to bad health and 0.196 fewer hours for COVID years 2020, 2021, and 2022, relative to 2019 and 2020. This provides us insight into how the pandemic may be negatively correlated with hours worked. However as demonstrated by Graph 1, there may be some indication of an increase in hours worked between 2019 and 2020 for those within public housing. Then the hours worked drop between 2020 and 2021, with a rise starting back up between 2021 and 2022. Simultaneously, the total hours worked for those in public housing saw a slight increase between 2018 and 2019 but then has slowly declined since.

Graph 1- Mean Hours Worked In Public Housing And Not In Public Housing (2018-2022)



[34] uhrsworkt(hat) = 39.71505 - 3.733524 (*pubhous_rev* = 0), so 39.71505 = *uhrsworkt pubhous*=0

[35] -3.733524(1/y) * 100 = -3.733524(1/39.51213) * 100 =-9.449%

Regarding controlling for demographics, we have variables *age*, *hsg*, *black*, and *female*. Our results show that the estimated hours worked is 4.852 less if the individual is female, relative to male, which is a striking difference. Furthermore, being Black increases estimated hours worked by 0.657 hours, relative to being non-Black, and having a high school diploma or GED increases hours worked by 1.841, relative to not having a high school education. Looking further into the lifestyles of those in public housing, we can use the *nchild* variable to denote that, with every additional child, estimated hours worked decreases by 0.029, all else equal. Lastly, in regard to age, a continuous variable, the model shows that with each additional year of age, estimated hours worked are expected to increase by 0.0342, all else constant.

Multiple Regression with Age^2: Model 8 (Table 4A)

From this model, through the *age_squared* variable, we can assess how the estimated hours worked change with an additional year of age in a manner that reflects the diminishing returns to age in terms of estimated hours worked. Estimated hours worked are predicted to increase by (0.0137 - 0.000147*age*), allowing us to evaluate the effect of an additional year of age on the total hours worked, all else constant. Adding a term that accounts for diminishing returns allows us to correct for the possibility of having exaggerated coefficients in prior models. Notably, this is the model with the highest R^2, meaning that this model is more explanatory based on the variables that we added.

Simple Log-Linear: Model 2 (Table 4B)

Table 4B- Log-Linear Regressions without Interaction Terms

	(1)	(2)
VARIABLES	Model 2	Model 4
pubhous_rev	-0.116***	-0.0916***
	(0.00698)	(0.00685)
good_health		0.0475***
		(0.00586)
nchild		-0.00514***
		(0.00152)
female		-0.150***
		(0.00314)
covid_year		-0.00378
		(0.00309)
black		0.0311***
		(0.00413)
hsg		0.0441***
		(0.00440)
age		0.00102***
		(0.000147)
Constant	3.639***	3.603***
	(0.00163)	(0.0103)
Observations	44,815	44,815
R-squared	0.006	0.058

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Similar to the simple linear regression in Model 1, the log-linear regression displayed in Model 2 shows that being in public housing appears to also decrease hours worked. Using the coefficient of *pubhous_rev* (β_1) estimates that being in public housing decreases hours worked by 10.95% compared to an individual who is not in public housing.[36] Similar to the simple regression in Model 1, this model is not ideal for drawing conclusions as there are no control variables. Model 2 shows the regression output for the sample log-linear regression, once again with the revised public housing, "*pubhous_rev*," as an independent dummy variable, and cleaned hours worked "*uhrsworkt*" as the dependent. The equation of the log-linear regression line is in the footnote.[37] The log-linear equation for estimated hours worked for someone in public housing is listed in the footnote as well.[38] Since *pubhous_rev* is a dummy variable, the β_0 = 39.71505, meaning the estimated hours worked is 39.71505 for those not in public housing. Solving the sample log-linear line,[39] semi-elasticity is -11.635%,[40] indicating that on average individuals who live in public housing's hours work show a decrease by 11.6%. It is worth noting that the number of observations for our sample linear regression model was 43,726 and for our log-linear sample regression line was 43,722. Our sample size for our log-linear sample model was only 4 less than that of our sample linear regression model, which is a negligible decrease regarding population representation. We did not solve for elasticity for either model because *pubhous_rev* is a dummy variable, therefore 1% increases in the independent variable are not applicable. Lastly, the SSE values of our simple linear regression and our log-linear regression cannot be compared because the dependent variable is in different forms.

Multiple Log-Linear Regression: Model 4 (Table 4B)

The multiple log-linear regression shown in Model 4 conveys that when using the coefficient of *pubhous_rev* (β_1), estimates that being in public housing results in an 8.75% decrease in hours worked compared to individuals not in public housing, holding all other variables constant. Interesting to note that in this regression model, being a female decreases hours worked by 13.9% relative to an individual who is not a female. This could be explained or consistent with Yelowitz who concluded that housing benefits impact labor force participation, especially regarding female heads of households with children (Yelowitz 2001).

Multiple Regression Models with Interaction Terms: Models 5, 6, 7, and 9

Table 5- Multiple Regression Models with Interaction Terms

	(1)	(2)	(3)	(4)
VARIABLES	Model 5	Model 6	Model 7	Model 9
pubhous_rev	-2.791***	-3.013***	-2.234***	-2.253***
	(0.366)	(0.249)	(0.485)	(0.558)
good_health	1.310***	1.308***	1.311***	1.309***

[36] (Exponent (b2-1) * 100) for Log-Lin Models

[37] *luhrsworkt*(hat) = 3.639308 - 0.1163575 (*pubhous_rev* = 1).

[38] *pubhous_rev* = 1, we get *uhrsworkt*= e^3.639398 = 38.0689123406

[39] *Uhrsworkt* is 39.71505 =39.71505 - 3.733524(*pubhous_rev* = 0)

[40] b1*100 = -0.1140139*100 = -11.4%

	(0.177)	(0.177)	(0.177)	(0.177)
nchild	-0.0291	-0.0300	-0.0288	-0.0300
	(0.0458)	(0.0458)	(0.0458)	(0.0458)
female	-4.846***	-4.852***	-4.853***	-4.846***
	(0.0971)	(0.0949)	(0.0949)	(0.0971)
covid_year	-0.196**	-0.195**	-0.195**	-0.195**
	(0.0934)	(0.0934)	(0.0934)	(0.0934)
black	0.657***	0.621***	0.657***	0.616***
	(0.125)	(0.130)	(0.125)	(0.130)
hsg	1.841***	1.841***	1.892***	1.894***
	(0.133)	(0.133)	(0.137)	(0.137)
age	0.0341***	0.0342***	0.0341***	0.0341***
	(0.00444)	(0.00444)	(0.00444)	(0.00444)
pubhous_rev_female	-0.135			-0.162
	(0.442)			(0.449)
pubhous_rev_black		0.423		0.502
		(0.447)		(0.454)
pubhous_rev_hsg			-0.791	-0.821
			(0.535)	(0.538)
Constant	38.19***	38.21***	38.15***	38.16***
	(0.312)	(0.312)	(0.313)	(0.313)
Observations	44,819	44,819	44,819	44,819
R-squared	0.067	0.067	0.067	0.067

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The following models incorporate interaction terms mentioned in Section III due to research explained in our literature review. Interpretations from prior models will stay the same, while the numbers of each have changed as demonstrated in Table 5. We will now discuss the interaction terms introduced in Models 5, 6, and 7.

Pubhous_rev Interaction with Female: Model 5 (Table 5)

Model 5 allows us to explore how the association between being in public housing on hours worked varies by gender, through the variable *pubhous_rev_female*. This is shown in our interaction term between the dummy variables *pubhous_rev* and *female*. According to our regression analysis, the marginal change from being in public housing and being female reduces estimated hours worked by 0.135 hours, holding all other variables constant. The change of predicted hours worked for those in public housing varies depending on whether they are female, relative to not. Predicted hours worked for someone in public housing if they are female is 2.926[41] fewer hours, whereas the change in predicted hours worked for those in public housing who are not female is 2.791[42] less. These calculations are made holding all other variables

[41] Difference $_{pubhous\_rev = 1\ female = 1}$= -2.791 - 0.135

[42] Difference $_{pubhous\_rev = 1\ female = 0}$= -2.791

constant. This may be because, as shown in our research, many women in public housing are single mothers (Yelowitz 2001). Therefore, they may be preoccupied with childcare and are not able to work as many hours. Another possible explanation for this is gender discrimination in the workplace for women with children.

Pubhous_rev Interaction with Black: Model 6 (Table 5)

Model 6 allows us to explore how the predicted hours worked for those in public housing on hours worked varies by race, specifically whether someone is Black or not, through the variable *pubhous_rev_black*. This is an interaction term between the dummy variables *pubhous_rev* and *black*. Through Model 7, we found that the change in predicted hours worked due to being in public housing varies depending on whether someone is Black or not. As shown in the coefficient of our interaction term, the marginal predicted change in estimated hours worked for being both in public housing and being Black is 0.423 more hours, all other variables held constant. The change in predicted hours worked for those in public housing is estimated to be 2.59[43] fewer hours if the individual also happens to be Black and 3.013[44] fewer hours if the individual is not Black, holding all other variables constant. This means although Black individuals in public housing still work less than people who are not in public housing, being in public housing and being Black increases one's estimated hours worked, compared to those who are not Black. This is consistent with the findings of the (Carlson 2009) which, as stated in Section II, concludes that public housing receipt had a positive, statistically significant impact on the earning and labor force participation of Black individuals and other minorities.

Pubhous_rev Interaction with High School Education: Model 7 (Table 5)

In Model 7, we observe how the change in predicted hours worked for those in public housing varies depending on whether an individual has a high school education or not. By observing the coefficient of our interaction term *pubhous_rev_hsg* we can denote that the marginal predicted change in hours worked for those in public housing with a high school education is 0.791 fewer hours. The predicted change in hours worked for those in public housing depends on whether they have a high school education. For those in public housing with a high school education, predicted hours worked are 3.025[45] less, relative to not, all else constant. For those in public housing without a high school education, predicted hours worked are 2.234[46] hours less, all else constant. This is very surprising; a possible explanation for this is that someone without a high school education in public housing is more likely to have multiple part-time jobs, rather than a single full-time job, so they work more hours.

Pubhous_rev Interactions: Model 9 (Table 5)

Model 9 incorporates all aforementioned interaction terms, *pubhous_rev_female*, *pubhous_rev_black*, and *pubhous_rev_hsg*, in a singular multivariable regression, offering us a more comprehensive interpretation of the relationship that our variables have with predicted hours worked. From this model, we notice that our main independent variable, *pubhous_rev*, maintains its statistical significance at the 1% level of significance across all models. Also, all additional variables, excluding interaction terms and *nchild* show statistical significance. All of these are at the 1% level of significance, except for *covid_year*, which is at the 5% level of

[43] Difference $_{pubhous\_rev = 1\ black = 1}$= -3.013 + 0.423

[44] Difference $_{pubhous\_rev = 1\ black = 0}$= -3.013

[45] Difference $_{pubhous\_rev = 1\ hsg = 1}$= -2.234 - 0.791

[46] Difference $_{pubhous\_rev = 1\ hsg = 0}$= -2.234

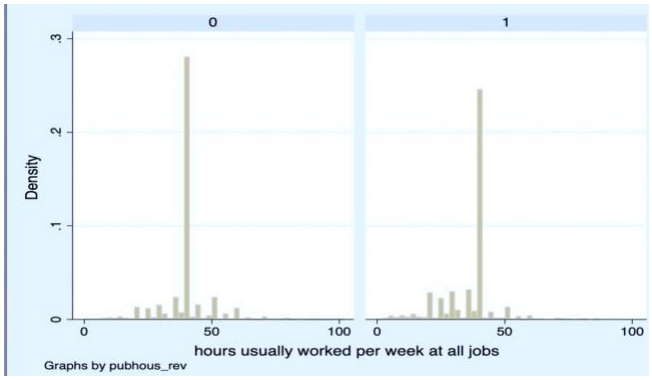
significance. Comparing Model 9 with Models 5, 6, and 7, we notice that no coefficients change signs or exhibit significant quantitative change.

The most notable changes occur in interaction terms *pubhous_rev_black*, *pubhous_rev_hsg*, and *pubhous_rev_female*, in descending order. The interaction term between being in public housing and being Black increases by 0.079, indicating that being both Black and in public housing marginally increases estimated hours worked by a higher amount with more controls for demographics. This is, once again, consistent with the findings of Carlson (2009). The coefficient for the interaction term between public housing and having a high school diploma or equivalent is 0.03 lower than it is in Model 7, indicating that being in public housing and having a high school education has a stronger negative association with estimated hours worked than before. We are surprised that interactions between public housing and female, Black, and being a high school graduate are not statistically significant with more endogenous elements controlled.

VI. Conclusion

Overall, our paper intends to examine if there is a significant relationship between public housing residency and weekly hours worked by looking at the years 2018 to 2022 to see if there is a shift or significant difference. While our results are not a clear indication of this relationship by any means nor is the methodology of the research conducted enough to fully answer the question, there may be a possible correlation between public housing residency and the total hours worked by these individuals. This can be seen by the varying skewness in Graph 3, with those in public housing having more right-skewed total hours worked. After controlling for certain variables like health, a high school graduate, demographics, and family size, there seems to be a reduction in total hours worked for being in public housing. When we controlled for health, as reflected in Model 3 there is a 1.31 coefficient for *good_health*=1 at the 1% significance level. The controlling for family size seen in the study conducted by Martinez (2002) found that hours worked decrease as the number of children increases. This is similar to Model 3, where the coefficient of *nchild* is -0.029. Though the coefficient is negative, as expected, it is not statistically significant, which we find surprising. In this same model, the level of significance for *covid_year* seems to be 0.05, while the level of significance for almost every other variable in the table has a level of significance of 0.01, which we also found striking.[47]

Graph 3-Histogram of Hours Worked according to Public Housing Residency



[47] Refer to Table 4A

Overall, across all models, the coefficient of *pubhous_rev* remains negative and statistically significant at the 1% significance level. This is affirmed by our hypothesis testing, descriptive statistics, demographic and lifestyle controls, and results.

In relation to past literature, the model results differ from that of the Association for Public Policy and Analysis and Management, which concludes that being in urban public housing has little to no effect on labor force activity. As shown, in all our models, the coefficient *pubhous_rev* is consistently statistically significant at the 1% significance level. However, our models are consistent with the findings of Carlson which assert that public housing positively affects the labor force participation of minorities, especially Black individuals. This is proven through our interpretation of the interaction term *pubhous_rev_black*, showing that for those in public housing, being Black has a marginal, positive change in estimated hours worked, relative to not, all else equal, by the coefficient of 0.423. Our interpretation of the interaction term *pubhous_rev_female* coincides with the findings of (Weinberg 2004), in that being a female in public housing marginally changes expected hours worked, all else equal by the coefficient of -0.135. Lastly, our research contests that of Reingold, who concluded that urban public housing is not a significant factor in labor activity (Reingold 2001).

Certain drawbacks and limitations of the study include the various measurement errors regarding all variables that can potentially divert our results. There is also a chance of multicollinearity between our explanatory variables such as *age* and *hsg*, meaning that they could potentially relate too much and affect the direct relationship of *pubhous_rev* to *uhrsworkt*. Also, the magnitudes of the sample sizes of those in public housing are significantly smaller than the pool of respondents who are not in public housing.[48] This disparity might influence the results we have, causing us to overestimate and/or underestimate the relationships between our variables. Additionally, our research focused more on controlling for demographics rather than controlling for neighborhoods. Neighborhoods can play a role in hours worked, as seen in our literature review because of job proximity, public transportation proximity, and community influences.

An interesting extension to this paper could be delving into the crime rate to see its correlation with the relationship between our two main variables. This could cause policymakers to better address the specific problem in communities with densely populated public housing residents. In addition, we advise that policymakers recognize a relationship between those in public housing and their employment. It is important to see the demographics of those in public housing and how there is potentially limited economic equity. Those in public housing already have limited income and could find themselves in a downward spiral as they are less likely to be fully immersed in the full-time workforce, once again leading to less earnings and not enough money to leave public housing. To alleviate this burden, governmental entities should create policies that support those in public housing by helping them find better opportunities not only to retain a full-time employment status but also to improve their personal health status. This could be done by offering additional benefits such as healthcare in the jobs that are taken by those in public housing or having a more robust healthcare system that would be expanded and create a path to increase the rates for receiving high school diplomas or the equivalent. This research could be further examined to discover the way that policy implementations truly help the development of the U.S. economy.

[48] Refer to Table 3 for sample sizes (N)

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IMPACT OF GOVERNMENT EDUCATIONAL EXPENDITURE ON FEMALE LABOR FORCE PARTICIPATION RATE WITH URBANIZATION EFFECT

Baiwei Han

Across the globe, there are significant gender gaps in labor force participation. This research analyzes the effect of government educational expenditure on female labor force participation (FLFP) rate, using an unbalanced country-level panel data between 2013 and 2022 with a two-way fixed effect model. The results suggest that government expenditure on education has a positive effect on FLFP rate, but this effect diminishes as expenditure increases until the turning point, with both country fixed and time fixed effect. Moreover, the negative coefficient on the interaction term of educational expenditure and urban population rates of -0.23 suggests that the quadratic relationship between educational expenditure and FLFP rate is weaker, and the turning point is 15.26% earlier, for countries with high urban population rates.

I. Introduction

Over the past decades, the world has made great efforts to achieve gender equality, yet there are still gender gaps and discrimination in the labor force market. The female labor force participation (FLFP) rate is a critical indicator that reflects society's value on gender equality and women empowerment. In 2022, the global male labor force participation rate was 72.5%, while the female labor force participation rate was only 47.3% (World Bank, 2022).

Previous studies have presented evidence of positive effect of education on the FLFP rate. Bloom et al. (2009) found that the positive effect of education on female labor force participation works through the reduction of fertility. According to the study results, an additional year of schooling reduces the fertility rate by 0.569 percentage point, and FLFP decreases by 10 – 15 percentage points with each additional child in the age group 25 – 39. In addition, government educational expenditure is closely related to female education by influencing women's access to education, years of schooling, educational attainment, and so on. In this paper, I use an unbalanced panel data at country level from 2013 to 2022 to investigate how the government expenditure on education directly affects the female labor force participation rate.

Given the positive relationship between female education and labor force participation rate for women, government expenditure on education is expected to have a positive impact on FLFP rates. However, under budget constraints, governments cannot invest indefinitely on education. One consequence of overspending on education is that the expenditure on other sectors such as health and social services is shrunk, which in turn leads to a decline in the labor force participation rate. Therefore, this research also aims to find a threshold of the percentage of government expenditure on education to total expenditure, so that the negative influence on FLFP rates can be avoided.

II. Literature Review

In previous empirical studies, economists have proposed a number of factors that could contribute to the female labor force participation, which focus on economic growth, education, fertility, urbanization, marital status, wages, and so on.

Ince (2010) suggests that in Turkey, improving female education levels has a positive effect on reducing fertility and unemployment rates, as well as enhancing female labor force participation.

Bawazir et al. (2022) find a positive and significant relationship between female tertiary education and female labor force participation, while the female secondary education negatively affects female labor force participation in the Middle East. They also suggest a negative effect of urbanization rate, which defined by urban population as a percentage of the total population, on female labor force participation.

Utilizing abortion legislation as an instrument for fertility, Bloom et al. (2009) find a significant negative effect of the fertility rate on female labor force participation, especially for women aged 20-39. The same inverse relationship between the FLFP rate and total fertility rate is found in 28 OECD countries by using panel cointegration and granger causality testing (Mishra and Smyth, 2010).

Economic growth is another indispensable factor when it comes to studying the FLFP. Plenty of studies present evidence of the U-shaped relationship between female labor force participation rate and economic development (Kumari, 2018). Mammen and Paxson (2000),

extending the results from Goldin (1995) that they use panel data, again find a clear U-shaped pattern - the poorest and richest countries have the highest FLFP rate.

III. Data and Descriptive Statistics

The dataset I use in this research is an unbalanced cross-country panel data covering the years from 2013 to 2022 for each of the 217 countries[49] around the world, leading to 2170 observations in total.

The dependent variable female labor force participation rate, which measures the proportion of the female population ages 15 and older that is economically active, is gathered from International Labor Organization Modeled Estimates (ILOEST). Compared to national estimates, the ILO modeled estimates include both nationally reported observations and imputed data for countries with missing data, which is beneficial to international comparisons of labor statistics (International Labor Organization, 2020).

The main independent variable government expenditure on education comes from UNESCO Institute for Statistics (UIS). It is the number of total government expenditure on education divided by the total general government expenditure on all sectors, measuring in percentage.

Table 1-Variable Descriptions

LFPfemale	Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate)
EduExp	Government expenditure on education, total (% of government expenditure)
EduExp2	Squared government expenditure on education
GDPpc	GDP per capita, PPP (constant 2017 international $)
gdppc_1000s	GDP per capita in $1000s
UrbanPop	Urban population (% of total population)
Urban	Urban = 1 if Urbanpop > median for all observations; 0 otherwise
Fertility	Fertility rate, total (births per woman)
TerEnroll	School enrollment, tertiary, female (% gross)
EduExp*Urban	Interaction term of government expenditure on education and urban

[49] 217 countries in this research represent 217 economies shown on the World Development Indicators (WDI)

The other four explanatory variables are GDP per capita (in thousands), urban population rates, fertility rates, and female tertiary enrollment rates. The data on GDP per capita in constant 2017 international dollars and total fertility rates are obtained from World Development Indicators (WDI). The data on urban population rates are collected by the United Nations Population Division. In this paper, I categorize the quantitative variable of urban population rates as a dummy variable *Urban*. In order to avoid the influence of outliers, I set the median number of urban population rates for all observations as the threshold. In this study, I will use the dummy variable *Urban* to represent the urban population rate. Lastly, female tertiary enrollment rates are collected by the UNESCO Institute for Statistics (UIS) based on an annual school survey. The indicator used in my research is a gross enrollment rate that includes students of all ages.

Table 2 presents the summary statistics for my main variables. On average, the female labor force participation rate is 50.31%, and ranges from 5.922 (Yemen in 2020) to 83.73 (Madagascar in 2022). The average and median government expenditure on education in the panel are both around 14%. The minimize expenditure of 1.705% was spent by Somalia in 2017, and the maximum expenditure of 35.01% was spend by Sierra Leone in 2019. It is noticeable that there are wide spreads in female tertiary enrollment rates with the standard deviation of 33.38%, and general increasing trends in most countries through 2013-2022.

Table 2-Summary Statistics

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
LFPfemale	1,864	50.31	14.51	5.922	83.73
EduExp	1,477	14.21	4.657	1.705	35.01
Fertility	1,892	2.656	1.329	0.772	7.344
TerEnroll	1,231	51.47	33.38	0.468	156.1
Urban	2,150	0.500	0.500	0	1
gdppc_1000s	1,929	21.32	22.09	0.708	157.6

IV. Empirical Model

To estimate how government expenditure on education affects the female labor force participation rate with both country fixed and time fixed effect, I construct the hypothesized population regression model as:

$$\boldsymbol{LFPfemale_{it} = \beta_1 EduExp_{it} + \beta_2 EduExp_{it}^2 + \beta_3 Urban_{it} + \beta_4 EduExp_{it} * Urban_{it} + \beta_5 gdppc\_1000s_{it} + \beta_6 Fertility_{it} + \beta_7 TerEnroll_{it} + \alpha_i + \lambda_t + u_{it}.}$$

Even though the predicted relationship between government educational expenditure and FLFP rate is non-linear, and this study focus more on the impact of a percent change rather than a unit change, both of my dependent variable *LFPfemale* and main independent variable *EduExp* are already measured in percentage. Therefore, the logarithmic model is not tested in my study.

Instead, I utilize the fixed effect quadratic model presented above to capture the possible nonlinear relationship and interpret the change of unit as a percentage point.

The continuous dependent variable *LFPfemale* is the female labor force participation rate in country *i* and year *t*. *EduExp* is the government expenditure on education, $EduExp^2$ is the quadratic term of *EduExp* to address the possible nonlinear relationship between *EduExp* and *LFPfemale*; *Urban* is the percentage of population living in urban areas categorized in dummy, *EduExp*Urban* is the interaction term to test the effect of urbanization; GDP per capita in thousands represented by *gdppc_1000s*, total fertility rate represented by *Fertility*, and female tertiary enrollment rate represented by *TerEnroll* are other control variables included in later regressions; α_i and λ_t are country and time fixed effect, respectively. All explanatory variables are selected based on the results of relevant studies mentioned in section 2. They are correlated with both government educational expenditure and FLFP rate.

As previous researches show the positive effect of education on female labor force participation (Ince 2010; Bloom et al. 2009; Bawazir et al. 2022), the predicted effect of government educational expenditure on female labor force participation rate is positive but diminishing as expenditure increases up until the turning point. The main explanatory variable *EduExp* is measured in the percentage of total government expenditure. I expect a smooth decline in the female labor force participation rate after a certain level of *EduExp*, because with a certain total budget, more expenditure on education means less expenditure on health care and social services, yet better health status expands opportunities for females to participate in the labor force (Osundina, 2020). Furthermore, this predicted quadratic relationship is expected to depend on if the country is urbanized or not. The interaction term *EduExp*Urban* is introduced as previous researches show that in urban areas, the workplace is located a distance from home, making it difficult for women to take care of children and work at the same time. Moreover, urbanization can also hinder female labor supply through the transition from agriculture to manufacturing and service sector (Goldin, 1995; Mammen and Paxson, 2000; Bloom et al. 2009). Nevertheless, urbanization may also create more paid job opportunities for women, so I include an interaction term to test if the relationship between educational expenditure and FLFP depends on urbanization and in what direction.

Figure 1-Relationship Between Educational Expenditure and FLFP Rate, Year 2018

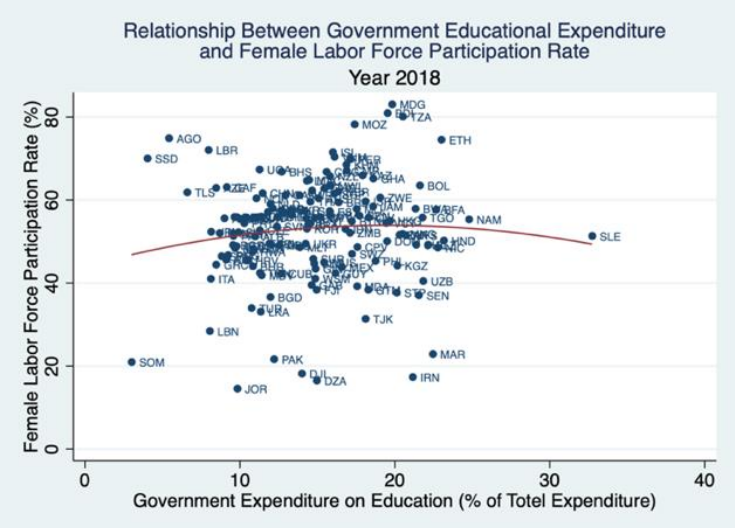

Figure 2-Relationship Between Educational Expenditure and FLFP Rate (Urban vs Non-Urban Countries[50]), Year 2018

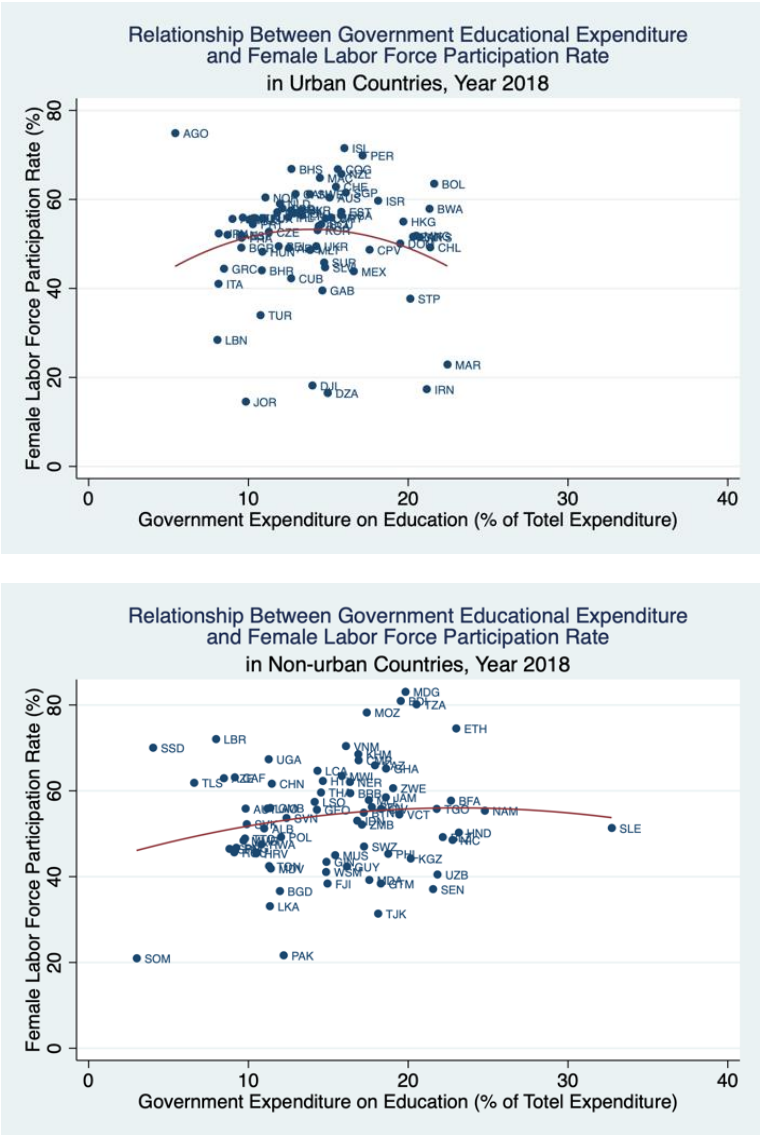

Figure 1 shows a slightly upside-down U-shaped curve for 145 countries with available data in 2018. It is worth noting that there is a sizable variation between countries. For example, in countries with similarly low educational expenditure around 3% - 5%, where South Sudan and Angola present high FLFP rates of 70% and 75%, respectively, but Somalia has a low FLFP rate of 21%. Figure 2 demonstrates that the female labor force participation rates are generally higher in urban countries. In urbanized countries with large service sectors, women have correspondingly more job opportunities.

[50] In this paper, urban countries correspond to countries with *Urban* = 1, and non-urban countries correspond to countries with *Urban* = 0

V. Description of Results

Table 3-Regression Results

VARIABLES	(1) OLS	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
EduExp	0.151	-0.0199	0.209**	0.293***	0.377***	0.343***
	(0.267)	(0.0386)	(0.0826)	(0.0941)	(0.138)	(0.127)
EduExp2			-0.00681***	-0.00841***	-0.00843**	-0.00757*
			(0.00257)	(0.00274)	(0.00421)	(0.00385)
Urban				2.576**	3.181**	3.399**
				(1.036)	(1.337)	(1.484)
EduExp*Urban				-0.104*	-0.213***	-0.231***
				(0.0571)	(0.0614)	(0.0602)
gdppc_1000s					0.0531***	0.0391***
					(0.0203)	(0.0135)
Fertility					0.891	
					(0.860)	
TerEnroll					0.0324*	0.0292
					(0.0187)	(0.0216)
Constant	50.58***	52.65***	50.90***	49.52***	42.86***	45.71***
	(3.700)	(0.555)	(0.661)	(0.853)	(2.640)	(1.694)
Observations	128	1,350	1,350	1,350	940	962
Adjusted R-squared	-0.005	0.000	0.009	0.015	0.048	0.073
Country FE	NO	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO	YES
Number of cty_name		166	166	166	143	143

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 reports the results of regressions. I start by running a simple linear regression with the dependent variable *LFPfemale* and the main independent variable *ExpEdu*, using cross-sectional data for 2021. The positive but statistically insignificant coefficient of 0.151 on *ExpEdu* states that there is no linear relationship between government educational expenditure and FLFP rate across countries. Given that plenty of time-invariant factors that are correlated to both *ExpEdu* and *LFPfemale* could make countries different from one another, I applied a country fixed effect from model 2 – 6 to test the relationship within a country. In model 2, the coefficient on *ExpEdu* is still statistically insignificant, indicating that the estimated relationship is not simple linear within the same country.

I then construct a squared term of *ExpEdu* and run a quadratic regression model to see if the relationship between *ExpEdu* and *LFPfemale* changes for different values of educational expenditure within a country. In model 3, one percentage point increase in educational expenditure is associated with a 0.209 percentage point increase in the FLFP rate. The negative coefficient of -0.007 on the quadratic term *ExpEdu2* is statistically significant at the 1% level, proving the nonlinear relationship. The increase in the government educational expenditure increases the education subsidy offered to low-income households. Thus, when a country allocates more funding on education, that same country is expected to see a higher female labor force participation rate until the turning point.

The interaction term *EduExp*Urban* added in model 4 has a significant negative coefficient of -0.104 at the 10% level, which proves that urban population rates do affect the relationship between *ExpEdu* and *LFPfemale*. Higher educational expenditure is associated with higher FLFP, and the effect is on average 0.104 percentage point smaller when *Urban* =1 than when *Urban* = 0. The main reasons behind the weaker effect on FLFP in urban countries could be the long distance from home and workplace, as well as the dominance of manufacturing which discourages FLFP. Besides, while urban areas are densely populated and economically developed, they generally have greater inequity than non-urban areas. Consequently, opportunities and government expenditure are unevenly distributed in urban areas, leading to a weaker increase in labor force participation.

After including GDP per capita, total fertility rate, and female tertiary enrollment rate as control variables, the coefficient on *ExpEdu* increases from 0.293 in model 4 to 0.377 in model 5. The change reflects that the coefficient on *ExpEdu* in model 4 is actually biased downwards and we underestimate the positive effect on FLFP. In model 5, the coefficient on *Fertility* is insignificant. Therefore, I decided to remove total fertility rate as a control variable since when running the regression without *Fertility*, the coefficient on *ExpEdu* increases from 0.377 to 0.404, which is less than half of the robust standard error of *ExpEdu*. After dropping *Fertility*, the quadratic relationship between *ExpEdu* and *LFPfemale* still presents.

Since plenty of omitted variables might also vary over time within a country, both country fixed effect and time fixed effect are included in model 6. The estimated effect of government educational expenditure drops to 0.343 when adding the time fixed effect, but it is still positive and significant at the 1% level. Combined with the coefficient of -0.008 on *ExpEdu2*, we can conclude that the quadratic relationship between *ExpEdu* and *LFPfemale* is robust even with both country and time fixed effect. An increase of government educational expenditure from 0% to 1% corresponds to 0.343 percentage points increase in FLFP when *Urban* = 0, and 0.112 percentage points increase in FLFP when *Urban* = 1. After that, each percentage point increase in educational expenditure keeps raising the FLFP, but at a declining rate. This result implies a declining marginal benefit of an increase in educational expenditure on female labor force participation. As the government expenditure on education reaches a higher percentage, the marginal benefits from increasing salaries and benefits, purchasing support services, offering subsidies would diminish. Under the final model, the turning point for non-urban countries is 22% educational expenditure. It suggests that once the government spends more than 22.66% of its total expenditure on education, the female labor force participation begins to decline. The turning point for urban countries is down to 7.4%, so the reduction of FLFP starts earlier at 7.4% expenditure on education. The predicted changes in *LFPfemale* for different values of *ExpEdu*, and the values of *LFPfemale* at the turning points when *Urban* = 0 and *Urban* =1 are presented in Table 4 on the next page with more details.

Table 4- Predicted Effects on LFPfemale for Different Values of ExpEdu

Δ *ExpEdu*	Δ *LFPfemale* when *Urban* = 0	Δ *LFPfemale* when *Urban* = 1
From 0% to 1%	0.343	0.112
From 5% to 6%	0.268	0.037
At 7.4%	-	0
From 10% to 11%	0.193	-0.038
From 15% to 16%	0.118	-0.113
At 22.66%	0	-

TerEnroll becomes insignificant in model 6; however, when removing *TerEnroll*, the coefficient on *ExpEdu* decreases from 0.343 to 0.256, and the change in coefficient is larger than half of the robust standard error of *ExpEdu*. Thus, *TerEnroll* is kept in the final model to reduce omitted variable bias. The regression result also shows a positive effect of GDP on FLFP rates. Holding other regressors constant, a $1000 increase in GDP per capita corresponds to a 0.04 percentage point increase in FLFP rate. The within adjusted r-squared keeps increasing and reaches a maximum of 0.073 in model 6, indicating that 7.3% in the variation of female labor force participation rate within a country is explained by the final regression model.

VI. Conclusion

Controlling for country fixed effect and time fixed effect, this research examines a quadratic relationship between government educational expenditure and female labor force participation rate. The Coefficient 0.343 on *ExpEdu* and the coefficient -0.008 on *ExpEdu2* imply that female labor force participation rates increase with government educational expenditure, but at a declining rate. Particularly, this relationship depends on the percentage of population living in urban areas. For countries with urban population rates below the median for all observations, the effect of government educational expenditure on FLFP rate is stronger by 0.231 percentage point, and the turning point of 22.66% expenditure is larger. For countries with urban population rates higher than the median, the turning point is down to 7.40% educational expenditure, followed by a decline in FLFP rate.

The results of this study suggest the significant role of government spending on education in improving female labor force participation rates. More policies should be implemented to help women in gaining access to education and labor force market. Expanding educational-related public subsidies, prolonging the duration of compulsory education, offering more paid jobs for women, and providing better work-family balance facilities are all valuable efforts to encourage female labor force participation. These investments on education are valuable given people with college degree or more generally have higher skills, more job opportunities, and higher earnings in prospect. Even though the educational expenditure directly benefits women who are in school, the return is long-lasting. Moreover, higher levels of education could also reduce the job discrimination and create more job positions for women, thereby indirectly enhancing female labor force participation.

VII. Limitations and Further Research

This research selects 217 countries around the world to investigate the impact of government educational expenditure on female labor force participation rate globally. Although the world FLFP rate presents a flat trend, the Middle East and North Africa (MENA), and South Asia keep showing low FLFP rates. In the MENA region, the FLFP rate was just around 20% over the past twenty years; in South Asia, the FLFP rate was right above 25% (World Bank, 2022). More research could focus on whether government expenditure on education has a stronger impact on the improvement of female labor force participation rate in these two regions.

Furthermore, based on this research, the turning point of 7.40% educational expenditure in urban countries is earlier than expected. The probable reasons could be that women in urbanized countries choose to go to graduate school rather than working immediately after college, and urbanized countries allocate different weights to each sector of the total expenditure. To further verify these reasons, female educational attainment, female years of schooling, and total government expenditure budgets could be included as explanatory variables in future studies. Moreover, it is noticeable that countries adopt different classifications[51] of urban and rural areas. Therefore, if some populous nations such as China and India change their definition of urban areas, my study results of the relationship between urbanization and FLFP rates may change significantly.

Lastly, the relationship between government expenditure on education and female labor force participation rate tested in this research could suffered from omitted variable bias. One better method to get a causal effect of education expenditure on FLFP rate is Regression Discontinuity Design (RDD) - exploiting a discontinuity in government transfers to municipalities at the population cutoff. In this case, it would be effective to change the unit of observation from country-year pair to state-year pair and look at states just above or just below the population threshold.

[51] The statistical concepts for estimating the urban population of each country that I used in this study came from World Urbanization Prospects 2018 version. The full list can be found at https://population.un.org/wup/Download/

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INFLUENCE OF MACROECONOMIC AND NON-MACRO FACTORS ON U.S. HOTEL STOCK RETURNS

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This study delves into the intricate relationship between macroeconomic and non-macroeconomic factors influencing the stock returns of hotel companies listed on the New York Stock Exchange. The comprehensive regression analysis encompasses essential macroeconomic variables such as the unemployment rate, rate on Consumer Loans at Commercial Banks, CPI, real M2 money stock, interest rates, exchange rate ($ to euros), and federal surplus/deficit. Notably, the analysis revealed that only two variables, unemployment rate and exchange rate significantly contribute to explaining the fluctuations in hotel stock returns. Regarding the non-macroeconomic variables, including the Covid-19 Outbreak, 2020 US Presidential Elections, Tokyo Olympics, Ukraine-Russia War, and Turkey-Syria Earthquake, only Covid-19 outbreak, and 2020 US Presidential Elections demonstrated statistical significance. The findings from this study provides valuable insights for investors, seeking investment opportunities within the hospitality industry.

I.Introduction

The hospitality industry, a crucial component of the global economy, operates within a dynamic framework shaped by an intricate interplay of macroeconomic and non-macroeconomic factors. In broader economic academic research, it is common to find explorations of papers exploring the nexus between macroeconomic variables, like interest rates and exchange rates, and stock returns. Recently, however, there has also been a growing interest in understanding the impact of non-macroeconomic factors, such as political events, natural disasters, and pandemics, which have been shown to cause significant volatility and influence investor sentiment. In this study, we embark on a comprehensive exploration of how these multifaceted dynamics collectively influence the stock returns of leading hotel companies listed on the New York Stock Exchange: The Castle Group Incorporation, InterContinental Hotels Group, Choice Hotels International, and Marriott International.

As the stock market undergoes constant transformations, a nuanced understanding of the relationships between economic indicators and stock performance becomes imperative for investors navigating the complexities of the sector. This study is aimed at extending this understanding. The paper is organized as follows: Section 2 reviews the existing literature; Section 3 describes the data and the variables used; Section 4 shows the regression analysis and the results; Section 5 concludes the paper and the future research required.

II.Literature Review

Prior research has established the significance of macroeconomic indicators in influencing stock returns. Barrows and Naka (1994) were the first to empirically assess the influence of macroeconomic conditions on the U.S. hospitality stock returns. Evidence shows that the inflation rate, money supply, and consumption have a significant explanatory content for forecasting stock returns.

Acikalin et al. (2008) investigated the relationship between macroeconomic variables and stock returns in the Istanbul Stock Exchange (ISE). Evidence was found that there was a strong correlation between how well the Istanbul Stock Exchange performs and macro factors such as GDP, interest rates, exchange rates, and current account balance.

Building on this narrative research, Pal and Mittal (2011) examined the long-term relationship between key macroeconomic variables and the Indian capital markets. They attempted to explore how the Indian stock market reacts to different macroeconomic variables. Macroeconomic variables such as interest rates, inflation rate, exchange rates and gross domestic savings (GDS) were used to demonstrate that changes in these economic factors can have a lasting impact on stock market performance.

While this research is relevant for understanding the macroeconomic impact on stock returns, attention has also been given to the importance of non-macroeconomic forces, including disasters, epidemics, terrorism, political events and financial crises, in affecting stock market returns. Chen et al. (2005) investigated the relationship between macro and non-macroeconomic factors and the hotel stock returns on the Taiwan stock exchange. Money supply, the growth rate of industrial production, expected inflation, the change of unemployment rate, and the yield spread were taken as macroeconomic variables. Among the macroeconomic factors only money supply and the unemployment rate significantly explained the movement of hotel stock returns. They also considered non-macroeconomic factors such as presidential elections, the 9/21

Turkey- Syria earthquake in 2023, the 2003 Iraq War, the outbreak of SARS, sports mega-events, the Asian financial crisis, and the 9/11 terrorist attacks. Notably, all the non-macro events had a significant impact on how hotel stocks performed.

Lee et al. (2020) delved deeper into the analysis of non-macro events and considered the relationship among the COVID-19 outbreak, macroeconomic fluctuations and hospitality stock returns. The results revealed that macroeconomic fluctuations and hospitality stock returns are significantly affected by shocks from the COVID-19 outbreak. Awadhi et al. (2020) also investigated the effect of the COVID-19 outbreak on stock market outcomes but took a broader approach. Their findings indicate that both the daily growth in total confirmed cases and in total cases of death caused by COVID-19 have significant negative effects on stock returns across all sectors.

This study builds upon the foundation provided by researchers by exploring a broader array of macroeconomic variables and incorporating non-macroeconomic events, in hopes of providing a comprehensive understanding of the factors shaping the hotel industry's financial landscape.

III. Data and Descriptive Statistics

This study focused on analyzing the stock performance of four hotel companies listed on the New York Stock Exchange: The Castle Group Incorporation, InterContinental Hotels Group, Choice Hotels International, and Marriott International. The study considers only stocks issued before November 2003 to ensure a comprehensive analysis over a suitable 20-year trading period, resulting in 240 monthly observations from November 2003 to November 2023. Monthly observations were chosen to minimize the effect of arbitrary daily fluctuations which may hinder broader results.

Table 1 provides detailed information on each company's stock, highlighting essential factors such as market capitalization and stock prices. Despite having the lowest market capitalization and stock price among the four companies, The Castle Group Inc. emerges as the oldest publicly traded hotel company in the dataset. Conversely, Marriott International, established later, boasts a larger market capitalization.

Table 1-Descriptive statistics of hotel companies

Company	Date of stock issued	Outstanding shares (in millions)	Forward dividend and yield	Beta (5Y monthly)	Market capitalization (in billions)
The Castle Group Inc.	Feb 2, 1995	10.06	1.40(1.82%)	1.38	3.72
InterContinental Hotels Group	April 10, 2003	164.75	1.43(1.94%)	0.91	12.202

Choice Hotels International	Oct 16, 1996	49.3	1.15(1.01%)	1.27	5.56
Marriott International	March 23, 1998	293.69	2.08(1.05%)	1.58	58.066

Figure 1-Monthly Stock Returns of Hotels

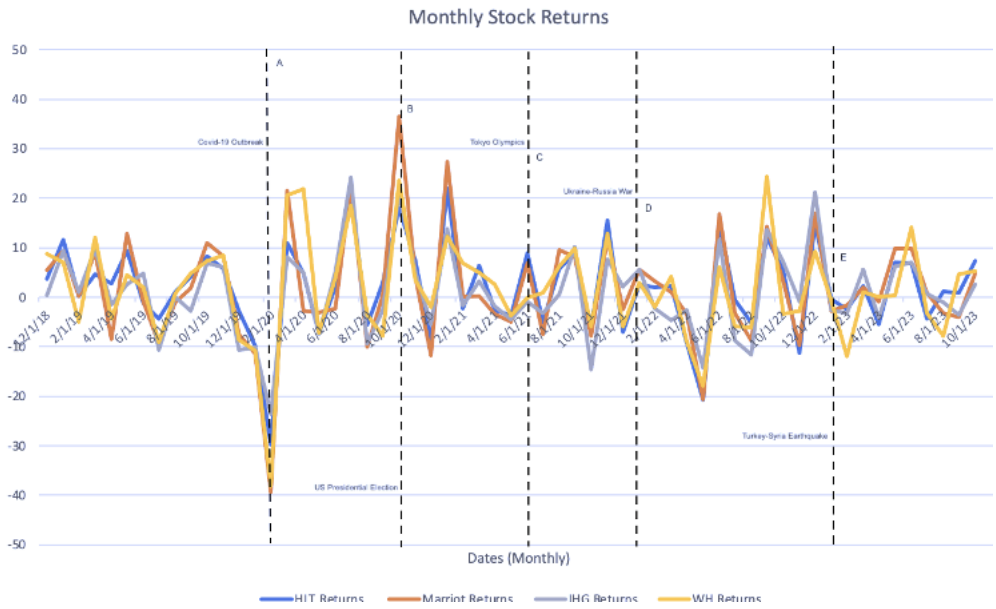
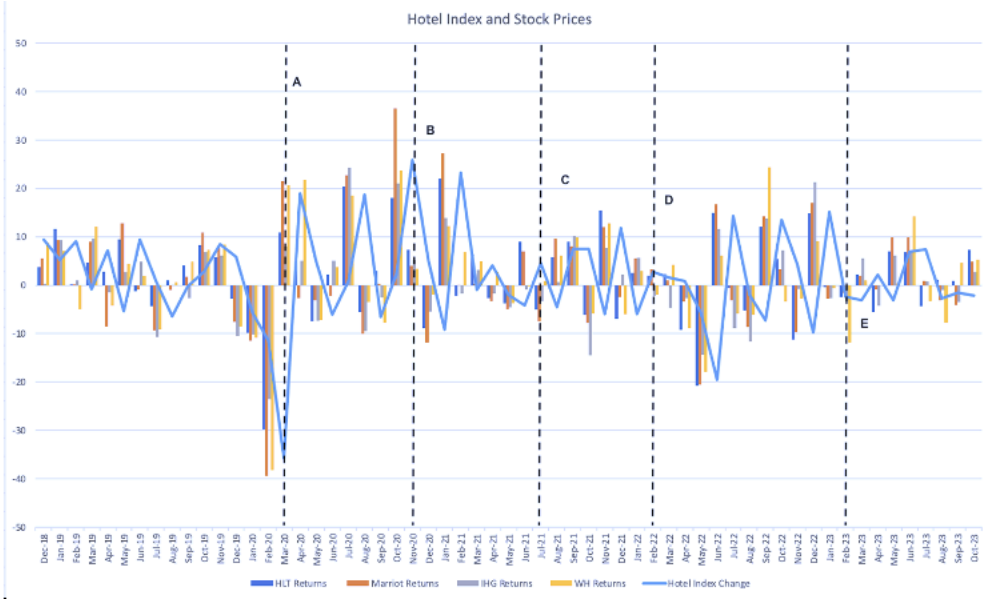


Figure 1 shows the monthly hotel stock returns of the four hotels we considered for the last five years from 2018 to 2023. The dotted lines represent the non-macroeconomic events with '*A'* representing Covid-19 Outbreak, '*B'* representing 2020 U.S. presidential election, '*C'* representing Tokyo Olympics, '*D'* representing the Ukraine-Russia War and '*E'* representing the Tokyo-Syria Earthquake. These annotations suggest an analysis of the impact of such events on stock performance, observable through shifts in the trajectory of the lines at these points. The sharp declines and spikes indicate a direct correlation between the event and stock returns, which is discussed further in the paper.

Figure 2 shows the aggregated hotel index performance against individual hotel stock prices over the same timeframe. The interplay between the lines shows how individual hotel stocks move in relation to the broader industry index, offering insights into whether certain stocks outperform or underperform the market. This is also discussed further in the paper.

Figure 2-Hotel Index and Stock Prices



The monthly hotel stock returns were then calculated from the changes in the value-weighted hotel price index. The hotel price index (HPI) was computed using the four stocks that we considered, and the following formulas were used to compute the returns ($\boldsymbol{R_t}$) and the HPI:

$$\boldsymbol{R_t = \left[\frac{[(HPI_t - HPI_{t-1})]}{HPI_{t-1}}\right] * 100}$$

$$\boldsymbol{market\ cap_n = stock\ price_n * outstanding\ stocks_n}$$

$$\boldsymbol{weight = \frac{market\ cap_n}{market\ cap_{n,n+1,n+2,n+3}}}$$

$$\boldsymbol{HPI = \frac{w(n) + w(n+1) + w(n+2) + w(n+3)}{4}}$$

The macroeconomic variables considered are the unemployment rate (UR), rate on consumer installment loans (C), consumer price index (CPI), M2 money stock (M2), interest rates (IR), exchange rates (EX), federal surplus/deficit (F). All data was taken from the Federal Reserve database and these variables are explained in detail in Table 2 with their correlations in Table 3. The highest correlations are between interest rates and M2 money supply at -0.69, exchange rate and M2 money supply at -0.68, and exchange rate and interest rate at 0.61.

Table 2 -Summary statistics of hotel stock returns and macroeconomic variables

	Mean	Minimum	Maximum	Standard Deviation
Returns	0.98	-44.6	32.1	8.1
Unemployment Rate	4.9	3.4	14.7	2.3
Rate on Consumer Installment Loans	5.3	3.2	7.8	0.86
CPI	3.5	1.5	6.6	1.6
M2 Money Stock	6809.1	5626.6	7671.9	743.1
Interest Rates	1.6	0.3	3.0	1.01
Exchange rates ($ to euros)	1.1	1.0	1.2	0.05
Federal Surplus or Deficit	-165900.9	-864074.1	308215.1	195428.3

Table 3 -Correlation and coefficient matrix

Returns	1.00							
Unemployment Rate	0.21	1.00						
Rate on Consumer Installment Loan	-0.12	-0.03	1.00					
CPI	-0.09	-0.29	-0.45	1.00				
M2 Money Stock	0.04	-0.27	-0.51	0.64	1.00			
Interest Rates	-0.05	0.40	0.62	-0.54	-0.53	1.00		
Exchange rates ($ to euros)	-0.17	0.50	0.38	-0.59	-0.61	0.17	1.00	
Federal Surplus or Deficit	0.05	0.10	-0.09	0.38	0.37	-0.26	-0.13	1.00

Unemployment rate is a lagging indicator of the job market's strength and states the percentage of the labor force without a job. It typically exhibits an inverse relationship with consumer spending, and, in theory, should have a negative impact on the stock market. However, it is noteworthy, however, that the unemployment rate has a positive relationship with stock returns, as suggested by Boyd et. al (2001). Rising unemployment is usually exhibited during an expansion phase, which signals a decline in interest rates, which tends to push stock prices up. This relationship is reflected in Table 3.

Consumer Price Index (CPI) is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. Douglason (2010) found a negative relationship between inflation and stock returns which is also reflected in the correlation table above.

M2 money supply stock is a measure of money supply that includes financial assets held by households such as time deposits, savings deposits, mutual funds, in addition to the liquid financial assets such as cash and checking deposits, generally defined by M1 measure of money. The rate of growth in the supply of money is highly correlated to the performance of stocks, with the correlation coefficient between S&P 500 and M2 money supply stock is near

perfect at 0.93 (Connor, 2023). But for the data we considered the correlation remains low at 0.04.

Exchange rate is a relative price of one currency expressed in terms of another currency. Gino et al. (2016) found that exchange rate movements have limited impact on stock returns, and Takawira et al. (2022) found the impact of exchange rates on stock market positive in the short run and negative in the long run. They also confirmed that the impact of interest rate and CPI had a much higher impact on stock returns than exchange rates.

The federal budget reflects the decisions of the federal government for the fiscal year. It includes decisions on taxes, borrowing, lending, and consumption. Darrat (1990) found evidence that federal policy exerts a lagged yet significant positive effect on stock returns even when the paths through volatile interest rates, real income, inflation, monetary policy, and exchange rates are all excluded. This positive relation is again reflected in table 3.

Gross domestic product (GDP) is a macroeconomic variable that is a widely acknowledged indicator of growth. However, it was not considered as it is available only on a quarterly basis and this restricts the analysis to a relatively smaller dataset.

IV. Model and Findings

Part 1: Regression model with macroeconomic factors

Table 4 describes the summary statistics and correlation between the stock returns and the seven independent variables. The mean of monthly hotel stock returns is 0.98%. Hotel stock returns seemed to have the highest correlation with unemployment rate (0.21) and exchange rate (-0.17) compared to all the other variables. Benoit (2011) studied various methods to normalize skewed data; one of them was to log it. Variable federal surplus/deficit has been subject to logarithmic transformation to achieve a more normal distribution, as it initially exhibited a skewed distribution.

Regression equation:

$$R_t = \beta_0 + \beta_1 UR_t + \beta_2 C_t + \beta_3 CPI_t + \beta_4 M2_t + \beta_5 IR_t + \beta_6 EX_t + \beta_7 ln(F_t) + \mu_t$$

Table 4-Multiple regression results

Variable	Constant	*UR*	*C*	*CPI*	*M2*	*IR*	*EX*	*F*
Coefficient	18.62	0.44	0.18	-0.06	0.08	-0.36	-10.81	0.34
t-stat	1.41	1.05	0.29	-0.97	0.50	-0.61	-1.69	0.37
p-value	0.16	0.07	0.77	0.09	0.62	0.54	0.33	0.57
R2 = 0.094	F-statistic = 1.10	Prob(F-statistic) = 0.01						
Coefficient	16.49	0.51	-0.26	-0.11	0.09	-1.23	—	0.25
t-stat	1.01	1.21	0.33	-0.94	0.49	-0.54	—	0.32
p-value	0.10	0.09	0.10	0.08	0.56	0.52	—	0.49
R2 = 0.097	F-statistic = 1.27	Prob(F-statistic) = 0.01						

The multiple regression results of hotel stock returns on macroeconomic forces are reported in Table 3. Only two variables, unemployment rate (U) and CPI exhibited statistical significance at $p < 0.1$. It is imperative though to validate the robustness of these findings, and to ensure that the observed significance is not due to multicollinearity.

O' Brian (2007) examined methods to measure multicollinearity. The first method is the Variance Inflation Factor (VIF). It measures how much the variance of an estimated regression coefficient increases if predictors are correlated. A VIF greater than 4 is often considered an indication of problematic multicollinearity. We can see that our value is around 1.03 which proves the lack of multicollinearity.

$$VIF = \frac{1}{1 - R^2} = 1.03$$

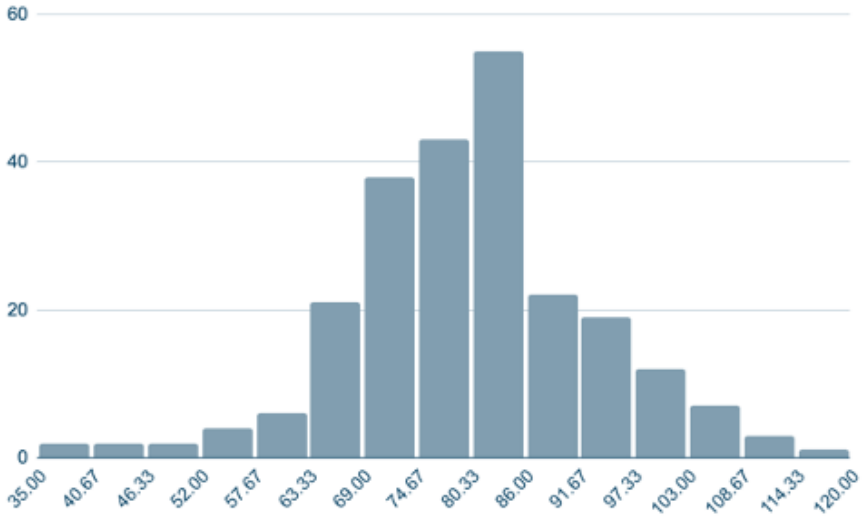
The second method for uncovering possible multicollinearity is Tolerance: the reciprocal of the VIF which provides a similar measure. Tolerance values less than 0.1 are often considered indicative of multicollinearity. From the calculation, the tolerance value is close to 1, which suggests normality.

$$T = \frac{1}{VIF} = 0.97$$

Normality in statistics refers to data distribution that follows a normal distribution, characterized by a symmetric, bell-shaped curve centered around the mean.

L Mansfield and Helms (1982) studied the impact of correlation on multicollinearity. High correlation coefficients (close to +1 or -1) between pairs of variables may indicate multicollinearity. Looking at table 2, none of the variables considered have a correlation close to +1 or -1, with the highest correlation being 0.64 between M2 money stock and CPI. They also looked at histograms to understand the impact of multicollinearity. Figure 3 depicts a histogram constructed using the residual values between the actual and predicted values of the dependent variable (Rt). The histogram's bell shape suggests normality, indicating that the residuals are distributed in a manner consistent with a normal distribution, which is essential for many statistical tests and methods to be valid.

Figure 3 - Histogram depicting normality



There was not a massive difference in the empirical results in the regression analysis even after the exchange rates (EX) variable was excluded. This aligns with existing evidence that exchange rates do not have a significant impact on stock returns (Gino et al., 2016). The same two variables (unemployment rate and CPI) significantly explained the return on hotel stocks. The overall explanatory power (adjusted R2 value) of the macroeconomic forces on hotel return was around 9% in both cases. This result aligns with the evidence found by Barrows et al. (1994) who reported that the explanatory power of the macroeconomic variables on hotel stock returns

was at 12%. Chen et al. (2005) also found evidence that macroeconomic variables have an 8% explanatory power on hotel stock returns.

Part 2: Regression model with non-macro factors

In this part of the analysis, the model was expanded to include non-macroeconomic elements in addition to the significant macroeconomic factors (exchange rate and unemployment rate) identified in part 1. A multiple regression analysis was conducted to evaluate the comprehensive explanatory capability of the model, now encompassing these non-macroeconomic variables.

In this model, variable *M* represents the macroeconomic variables that have a significant correlation with hotel stock returns. Variable *NM* stands for the non-macroeconomic variables, conceptualized as dummy variables. These dummy variables are assigned a value of 1 for the specific month coinciding with the event and 0 in all other periods. The non-macro-economic variables considered were COVID-19 outbreak, covering March 2020 to December 2020, the U.S. Presidential Election covering October 2020 to December 2020, Tokyo Olympics covering June 2021 to August 2021, Ukraine-Russia War covering February 2022 to November 2023, and Turkey-Syria Earthquake covering February 2023 to March 2023.

The regression model used in Chen et al. (2005) and Yip et al. (2007) identified significant macro-economic variables and combined with a dummy variable interaction for non-economic variables. Their model was used to calculate returns of hotel-stocks:

$$\boldsymbol{R_t = \beta_0 + \sum_{i=1}^{n} \beta_i M_{it} + \sum_{i=1}^{n} \gamma_j NM_{jt} + \mu_t}$$

The regression analysis forecasts hotel stock returns by incorporating both macro-economic indicators and event-specific variables. Macro-economic influences are captured by M_{it} and quantify the impact on stock returns. To account for unique, time-sensitive events that may affect the market, a dummy variable j is considered, marked as ‘1’ during the event month and ‘0’' at other times, enabling us to isolate the event's impact.

Table 5-Multiple regression results

Variable	Constant	*Covid-19*	2020 Presidential Election	*Tokyo Olympics*	*Ukraine-Russia War*	*Turkey-Syria Earthquake*
Coefficient	22.61	-12.32	10.42	3.10	2.32	-0.43
t-stat	18.42	- 8.90	8.21	2.44	1.29	-0.30

p-value	0.02	0.01	0.07	0.09	0.23	0.14
R2 = 0.34	F-statistic = 4.1	Prob(F-statistic) = 0.01				

Table 5 shows the regression analysis of the hotel stock returns on non-macroeconomic variables controlling macroeconomic risks. Out of the five variables considered, only Covid-19 ($p > 0.05$) and 2020 Presidential Elections ($p > 0.1$) were statistically significant. Both these variables had a bigger impact on the hotel stock returns in the U.S. relative to the other factors. The 2020 Presidential Election had a positive impact whereas Covid-19 had a negative impact and the same is shown in Figure-2.

The advent of the Covid-19 pandemic had a detrimental impact on hotel stock returns, primarily due to the strict travel restrictions and a hesitance to engage in travel, both of which led to a reduction in hotel occupancies. This downturn is reflected in lack of investor confidence, as the market anticipated the contraction of revenue streams for hospitality establishments. (Kanamura, 2022).

Conversely, the aftermath of the 2020 U.S. Presidential Election injected a dose of optimism into the market, as investors foresaw a potential for economic stimulus and policy initiatives conducive to travel and hospitality recovery. The positive response in hotel stock returns post-election can be attributed to the anticipated stabilization of the economy, with potential for renewed travel demand bolstering the hospitality sector, thus improving stock performance amidst the ongoing challenges posed by the pandemic. This is reflected almost always post presidential elections, where last minute rises in hotel bookings are known as ‘election escapes’ (Presser, 2020).

Lawrence et al. (2021) found that the Olympics does have a significant impact on the stocks that relate to the games, such as social media company stocks, hotel stocks, and sponsors stocks. Most of these positive impacts on stocks are exclusive to those linked to the Olympics organization, such as Comcast Corporation which holds the broadcasting rights for the Olympics in the U.S. The above study only measures the impact on U.S stock returns which may be the reason the Tokyo Olympics exhibit no significant impact.

The Ukraine-Russia conflict and the Türkiye-Syria earthquake do not have had a significant impact on U.S. hotel stock returns due to a variety of factors. Primarily these events, while geopolitically significant, likely did not directly affect the fundamental drivers of the U.S. hospitality market, such as domestic travel demand and operational costs. Additionally, the response to such geopolitical crises is often complex, and investors may have already weighed in some of the anticipated risks.

V. Conclusion and Future Research

The study established that the significant influences on hotel stock returns were predominantly linked to the unemployment and exchange rates among macroeconomic variables, and to the Covid-19 pandemic and the 2020 Presidential Election among non-macroeconomic factors. The pandemic exerted a negative effect on stocks due to imposed travel restrictions,

whereas the election had a positive influence, likely stemming from investor optimism about economic recovery. This research underscores the intricate relationship between hotel stock performance and a mix of macroeconomic indicators and significant societal events, offering vital insights for investors and policymakers.

The empirical findings from this study hold substantial implications for both the academic domain and investment community, delineating the nuanced interplay between macroeconomic and non-macroeconomic variables and their consequential impacts on hotel stock returns. For investors, the elucidation of the significant correlations between hotel stock performance and variables such as the unemployment and exchange rates, alongside the discernible effects of the Covid-19 pandemic and the 2020 Presidential Election, serves as a critical input for formulating investment strategies. This analysis affords investors a more comprehensive framework for risk assessment and portfolio management, underscoring the necessity of integrating a wide array of economic indicators and external events into investment decision-making processes.

For the scholarly community, these insights contribute to the extant literature by pinpointing the specific dynamics that influence the hospitality sector, particularly in the wake of unprecedented global challenges. The study's call for further exploration into sector-specific impacts, technological innovations, and the integration of environmental and social governance factors presents a forward-looking research agenda that resonates with contemporary economic concerns and societal shifts. Such inquiries are poised to not only advance academic understanding but also to yield pragmatic insights for policy formulation, strategic business planning, and the broader discourse on sustainable economic practices.

Moreover, the study’s emphasis on comparative international analysis and the investigation into the long-term ramifications of periodic events like elections and financial crises on market sentiment and industry performance underscores the importance of a holistic, global perspective in financial analytics. This perspective is imperative in the current globalized market landscape, where regional events can precipitate wide-reaching effects across the international economic system.

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MODELING THE INTERCONNECTION BETWEEN GLOBAL POVERTY RATES AND CO_2 EMISSIONS: AN EMPIRICAL APPROACH

Susan Shobeiri

Simultaneously addressing the challenges of poverty and environmental degradation continues to be a central priority in the pursuit of sustainable development objectives (Baloch et. al. 2020). This paper utilizes panel data from 162 countries from 1991 to 2020 to determine whether countries with lower poverty rates are associated with higher carbon dioxide (CO2) emissions. A statistically significant non-linear, negative relationship is found: a one percentage point increase in poverty rates is associated with a 0.74% decrease in expected per capita CO2 emissions, when holding constant access to electricity, urban population, and accounting for country- and year fixed effects.

I. Introduction

In light of escalating concern surrounding greenhouse gas emissions and their far-reaching environmental repercussions, international discourse on sustainable development practices has intensified. International policy on the matter has notably focused on the unequal impacts and origins of emissions, particularly focusing on the distinction between the emissions from developing and developed nations (Duong & Flaherty 2020). Given the simultaneous developmental goals of poverty alleviation and carbon dioxide emissions reductions, much research has been conducted on the relationship between poverty and CO2 emissions, such as Baloch et. al. (2020), Rizk & Slimane (2018), and Haoyen et al. (2023). Additionally, it is difficult to maintain a consensus amongst the international community, given the resources required to eradicate poverty and the consumption patterns of higher income nations (Wollburg et al., 2023). With this tension in mind, this paper aims to answer the question: Are countries with lower poverty rates associated with higher CO2 emissions? Wollburg explains that rising income and consumption levels have been the main drivers of increasing CO2 emissions historically. Therefore, it is expected that there is a negative relationship between poverty rates and CO2 emissions. A non-linear relationship between the variables is also expected, as a percentage change in CO2 emissions is anticipated to have a similar effect rather than a change in metric tons, given the dramatic disparities between countries at different stages of development.

The analysis that follows explores the current proposed relationships between poverty, carbon emissions, and a variety of other socioeconomic factors. Then I will describe and utilize existing panel data across 162 countries to construct an empirical model of the relationship between poverty rates and CO2 emissions. Finally, I will compile my findings and provide a framework for understanding the observed relationships. The log-linear model presented concludes that there exists a statistically negative relationship between poverty rates and CO2 emissions at the 1% level. The final model demonstrates that a one percentage point increase in poverty rates is associated with a 0.74% decrease in expected per capita CO2 emissions, when controlling for access to electricity, percentage of the population residing in urban areas, and including country- and time-fixed effects.

II. Literature Review

Much literature relating poverty and CO2 emissions has found a non-linear relationship between the two variables. Rizk and Slimane (2018) utilize a fixed effects cubic model with logged CO2 emissions, controlling for urban population, life expectancy, and industry value added. They find that a non-linear, inverted N relationship between CO2 and poverty exists, meaning the relationship wears off at a certain level of poverty. Put differently, to have a negative relation between poverty and emissions, a country must be above a certain threshold level of poverty (Rizk & Slimane, 2018). They outline this as a key finding, demonstrating that poor countries tend to be major victims of environmental degradation, but do not play a major role in its cause.

At the country level, Haoyen et al. (2023) found that the implementation of poverty alleviation policy aggravated CO2 emissions in China, as poverty alleviation promotes consumption and production. They model this using logged CO2 emissions, with variables for the size of the population, per capita disposable income, industrial structure, and afforested area.

They utilize this model to conclude that a reduction in poverty will significantly increase carbon emissions (Haoyen et al., 2023). In analyzing the relationship with poverty as the dependent variable, Haoyen et al. (2023) conclude there is an inverted U-shaped relationship, meaning that carbon reduction first increases poverty before passing the turning point, where poverty then declines. Thus, the impact of carbon on poverty depends on the level of poverty. These findings carry important policy implications and point toward the necessity of applying considering poverty level across countries when determining environmental impacts.

In continuing to explore the relationship with carbon emissions as the independent variable, Duong and Flaherty (2022) find that carbon emissions, coupled with inequality, exacerbate poverty. Their model utilizes poverty as the dependent variable to interact with GDP, CO2 emissions, and inequality. Furthermore, the effect of emissions on poverty is stronger for countries at higher poverty levels (Duong & Flaherty 2022). Their findings demonstrate the importance of considering the disproportionate impacts of climate change on poorer nations when formulating international policy.

Existing research takes multiple varied approaches, with a general emphasis on poverty alleviation rather than poverty rates themselves. Moreover, CO2 emissions are often explored as a factor impacting poverty, rather than the other direction. This paper seeks to provide clarity on the direct relationship between poverty rates in a country and that country's CO2 emissions, so that international policy may be grounded in a more comprehensive understanding of how affluence and emissions are fundamentally linked.

III. Data and Descriptive Statistics

This research utilizes panel data at the country level from the years 1991 to 2020 in order to observe a possible relationship between poverty rates and CO2 emissions. Information for each variable has been collected from 162 countries, and the unit of observation is a country year pair, with 1,719 total observations in the final model.

Data corresponding to each variable is from the World Bank's World Development Indicators. In particular, poverty rates are measured by the poverty headcount ratio at $6.85 a day, at 2017 international prices (PPP). The World Bank's database draws on detailed consumption and income data from over 2000 household surveys across 169 countries.

Carbon emissions are quantified using CO2 emissions in metric tons per capita. Data for carbon dioxide emissions include gasses released from the burning of fossil fuels and cement manufacture. The data excludes, however, emissions from land use such as deforestation. The World Bank's emissions data is sourced from the World Resource Institute's Climate Watch Historical GHG Emissions from 1990 to 2000.

Access to electricity is measured as the percentage of the country with access using data from the World Bank's Global Electrification Database collected from industry, national surveys, and international sources. Data on the Gini index is drawn from household survey data obtained by government statistical agencies, World Bank country departments, and the Luxembourg Income Study database. The Gini index measures the distribution of income or consumption among individuals and households, enumerating the extent to which an economy deviates from an equal distribution of income. Gross domestic product (GDP) is measured as GDP per capita, in 2017 PPP. Data on the percentage of people living in urban areas is collected by the United Nations Population Division.

Table 1-Variable Descriptions

poverty	Poverty headcount ratio at $6.85 a day (% of population)
povsq	poverty squared
co2perc	CO_2 emissions (metric tons per capita)
co2pclog	log(co2perc)
accesstoelec	Access to electricity (% of population)
pov_elec	Interaction Term: poverty*accesstoelec
gini	Gini index (%)
gdp	GDP per capita, PPP (constant 2017 international $)
urbanpop	People living in urban areas (% of population)

Table 2-Summary Statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
accesstoelec	6,101	81.43	29.34	0.534	100
co2pc	5,919	4.236	5.434	0	47.66
gdp	6,094	18,305	20,548	436.4	157,602
gini	2,009	37.90	8.875	20.70	65.80
poverty	2,013	32.57	33.29	0	100
urbanpop	13,545	51.63	25.71	2.077	100
Number of country_num	162	162	162	162	162
	(1)	(2)	(3)	(4)	(5)

IV. Empirical Model

I estimate a model to construct logged CO2 emissions as a function of poverty rates, access to electricity, the percentage of the population living in urban areas, and GDP using country level and time fixed effects from the compiled data set as follows:

$$\ln(co2pc)_{it} = \beta_0 + \beta_1 poverty_{it} + \beta_2 accesstoelec_{it} + \beta_3 urbanpop_{it} + \beta_4 gdp_{it} + \alpha_i + \gamma_t + u_{it}$$

Within this fixed-effects model holding time *t* and country *i* constant, *ln(co2pc)* represents the CO2 emissions per capita in country *i* and time *t*, measured in percentage due to the logged variable. *co2pc* is the dependent continuous variable of this equation. The regression is nonlinear and utilizes a logged dependent variable, as much of the existing research has done, such as Haoyen et al., 2023 and Rizk & Slimane, 2018. The main independent variable, poverty, in country *i* and time *t* is expected to have a negative coefficient as it is predicted that lower poverty rates will be associated with higher per-capita CO2 emissions due to related consumption patterns. To account for potential omitted variables, I expect to test for multiple explanatory variables. The coefficient on the first control variable, *accesstoelec*, is expected to be

positive as countries with higher rates of access to electricity are expected to have higher CO2 emissions, due to the resource use associated with electricity generation. The coefficient on the second control variable, *urbanpop*, is expected to be positive as countries with greater proportions of urban populations are expected to have higher CO2 emissions, as cities are associated with industrial and transport systems that rely on fossil fuels and infrastructure constructed with carbon-intensive materials (Rizk & Slimane, 2018). The coefficient on *gdp* is also expected to be positive, for similar reasons regarding consumption causing the anticipated relationship between lower poverty and higher emissions.

This panel data set at the country level analyzes the years 1991 to 2020 and the model accounts for this in the time variable λ_t, which controls for any factor that varies across time but not across entities. Variable α_i controls for all time-invariant factors that make countries different from one another. This estimated model explains how a percentage point increase in poverty associated with percentage decreases in expected CO2 emissions, holding constant for access to electricity, urban population, GDP, and considering country and time-fixed effects.
As seen below, Figure 1 is a scatterplot representing the relationship between poverty and per capita CO2 emissions for 75 countries in 2017. The fitted values demonstrate a negative relationship between the variables in a cross-sectional, simple linear approach. The scatterplot demonstrates potential nonlinearity with the largest outliers, like Canada and Kazakhstan, occurring at lower poverty rates. When utilizing a logarithmic dependent variable for the same year in Figure 2, the log-linear model appears to be the most appropriate as it visually demonstrates the least variation.

Figure 1-Scatterplot of Poverty Rates and CO_2 Emissions, 2017

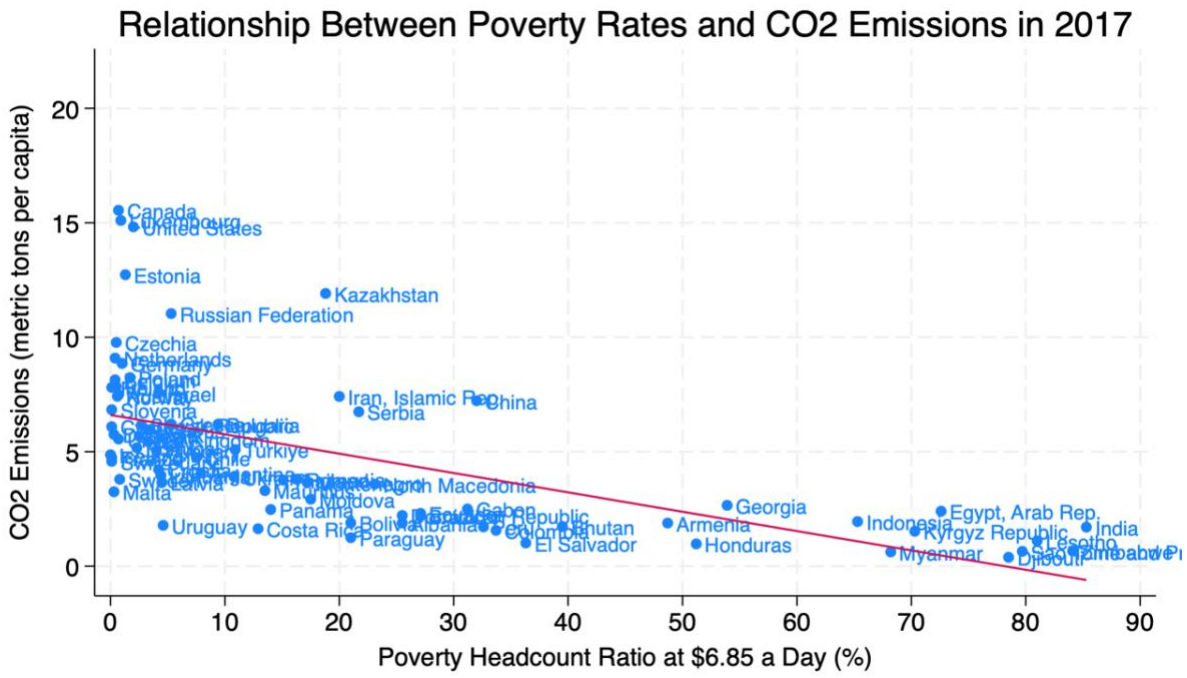
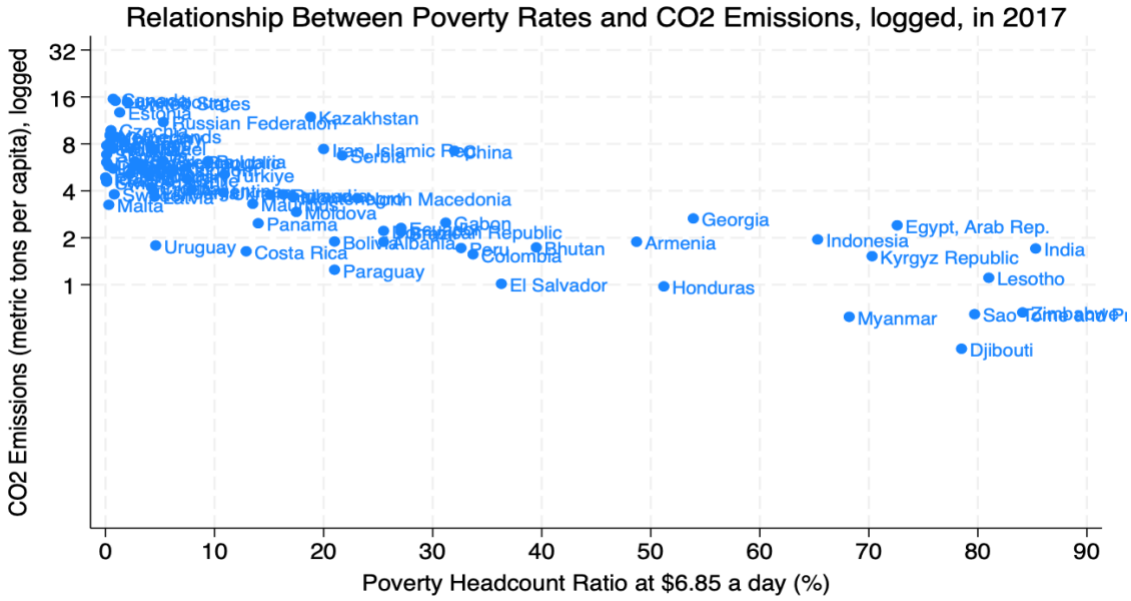


Figure 2-Scatterplot of Poverty Rates and logged CO_2 Emissions, 2017



V. Description of Results

Table 3-Regression Results 1

VARIABLES	(1) co2perc	(2) co2perc	(3) co2perc	(4) co2perc	(5) co2pclog
poverty	-0.0845***	-0.0230***	-0.0535***	-0.0456**	-0.0103***
	(0.00982)	(0.00679)	(0.0113)	(0.0203)	(0.00244)
povsq				-8.42e-05	
				(0.000171)	
Constant	6.607***	5.844***	7.399***	7.343***	1.192***
	(0.467)	(0.223)	(0.796)	(0.816)	(0.132)
Observations	75	1,806	1,806	1,806	1,805
Adjusted R-squared	0.347	0.049	0.249	0.249	0.275
Country FE	NO	YES	YES	YES	YES
Year FE	NO	NO	YES	YES	YES
Number of country_num		165	165	165	165

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 explores the relationship between poverty and CO2 emissions, testing for nonlinearity in country and time fixed effects. In a cross-sectional simple linear regression from the year 2017, increasing poverty by one percentage point is associated with a 0.0845 metric ton decrease in expected per capita CO2 emissions. The coefficient on *poverty* is statistically significant at the 1% level. The negative correlation aligns with my hypothesis, as the intense resource use of more affluent nations likely contributes to increases in their carbon footprint. The next model incorporates country-fixed effects, maintaining a slightly weaker negative relationship that continues to be statistically significant at the 1% level. When incorporating both country and time fixed effects in Model 3, the relationship remains negative and statistically significant at the 1% level. As such, all further models will include both entity and time-fixed effects.

Model 4 then tests for a quadratic relationship. Since the coefficient on the squared poverty term is statistically insignificant, the term is not included in the model. Finally, CO2 emissions are logged, and the model once again results in a negative coefficient on poverty that is statistically significant at the 1% level. To compare the linear y model to the log y model, I utilized several procedures to standardize values across the models, which resulted in a value of .46023. Because this value is greater than the R squared within Model 3, 0.2617, I proceeded with a log-linear model. I did not log *poverty* as the variable is measured as a percentage.

Table 4 - Regression Results 2

VARIABLES	(1) co2pclog	(2) co2pclog	(3) co2pclog	(4) co2pclog
poverty	-0.00830***	-0.0160***	-0.00893***	-0.00740***
	(0.00196)	(0.00612)	(0.00214)	(0.00182)
accesstoelec	0.0195***	0.0127**	0.0198***	0.0176***
	(0.00241)	(0.00503)	(0.00277)	(0.00247)
gini			0.00398	
			(0.00370)	
gdp			3.56e-07	
			(3.44e-06)	
pov_elec		7.74e-05		
		(5.62e-05)		
urbanpop				0.00995**
				(0.00500)
Constant	-0.271	0.392	-0.431	-0.726**
	(0.242)	(0.508)	(0.352)	(0.349)
Observations	1,730	1,730	1,709	1,719
Number of country_num	163	163	159	162
Adjusted R-squared	0.411	0.414	0.417	0.408
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Table 4, the relationship between poverty rates and CO2 emissions is further explored by considering other variables, such as *accesstoelec.* All models control for country and time-fixed effects and are log-linear models.

The first factor that is controlled for is the percentage of the population that has access to electricity. The coefficient on *accesstoelec* is statistically significant at the 1% level. Adding this variable changed the coefficient on poverty from -0.0103 to -0.00830. This result indicates that without *accesstoelec*, the model had negative bias and was overestimating the relationship between poverty and CO2 emissions. As such, *accesstoelec* is kept in the model to prevent omitted variable bias. In this model, a one percentage point increase in poverty is associated with a 0.83% decrease in per capita CO2 emissions, controlling for access to electricity and considering country and time-fixed effects.

Due to the potential differences in per capita CO2 emissions based on the level of access to electricity a country has, I then tested an interaction term model between poverty and access to electricity in Model 2. Since the coefficient on the interaction term was statistically insignificant, I dropped the interaction term from future models. This means that the relationship between poverty and CO2 emissions does not depend on the percentage of the country's population with access to electricity. In other words, an associated increase in CO2 emissions from an increase in access to electricity does not vary with poverty rate.

I then added variables for the Gini index and per capita GDP as these factors are related to poverty rates and CO2 emissions and could bias the coefficient if unaccounted for. The coefficient on *poverty* did not, however, change by more than half of a standard error, so there was no evidence of omitted variable bias. Both the coefficient on *gini* and the coefficient on *gdp* were statistically insignificant. Before dropping the variables from the model, I ran a joint-F test which found them jointly insignificant, providing additional reasoning for removing the variables from the model. Moreover, when *gini* and *gdp* were added to regressions without considering country- or year-fixed effects, they were statistically significant and provided evidence of omitted variable bias. As such, these variables are likely being captured by entity and time-fixed effects. Furthermore, GDP per capita is highly related to a country's poverty rate, so multicollinearity could be a factor explaining its insignificance when added to the model. When *gdp* and *gini* were added, the standard error on the coefficient of poverty increases, demonstrating that multicollinearity could be present.

Finally, I controlled for the percentage of the country's population that lives in urban areas because cities can be hotspots for both carbon emissions and concentrated poverty. Model 4 demonstrates that models without *urbanpop* had negative bias and overestimated the relationship between poverty and CO2 emissions, as the coefficient on poverty changed from -0.00830 to - 0.00740 when controlling for *urbanpop*. Here, the coefficients on *poverty* and *accesstoelec* are statistically significant at the 1% level, and the coefficient on *urbanpop* is statistically significant at the 5% level. Thus, when a country has a one percentage point increase in poverty, that country is expected to have a 0.74% decrease in per capita CO2 emissions, when controlling for access to electricity, urban population, and including country- and time-fixed effects. This aligns with my hypothesis of a negative, nonlinear relationship between the variables. 40.8% of the variation in CO2 emissions is explained by this log-linear, country and year-fixed effects model. While this is not the model in which poverty explains the highest amount of variation in CO2 emissions, it is the best model as it accounts for omitted variable bias. Put differently, the model is the most parsimonious it can be while appropriately addressing factors, like access to electricity and the percentage of urban population.

V. Conclusion

This research provides statistically significant evidence of a nonlinear, negative relationship between poverty rates and CO2 emissions, aligning with the expected hypotheses. When accounting for country-level and time-fixed effects and holding access to electricity and percentage of the population residing in urban areas constant, a one percentage point increase in poverty rates is associated with a 0.74% decrease in expected per capita CO2 emissions. Given the intense consumption patterns of wealthier countries, this relationship was anticipated and demonstrates that countries with lower poverty rates are expected to have higher CO2 emissions.

The model demonstrates the importance of considering the affluence of nations when implementing international climate policy initiatives. Despite accounting for much fewer global emissions, impoverished nations often face greater consequences from climate change (Duong & Flaherty 2022). As intergovernmental bodies like the United Nations move forward in setting global goals and standards, this relationship must be understood as a central tenet. In particular, the simultaneous goals of poverty alleviation and carbon emissions reduction must be implemented in a manner that is equitable insofar as it considers the existing disparities across nations such as those highlighted in this paper. It is imperative to strike a balance between economic progress and ecological well-being, ensuring that the benefits of development are shared equitably and that regulatory frameworks are in place to mitigate the environmental impact of economic prosperity.

VI. Limitations and Further Research

The biggest limitations in this research are due to inadequate data and an unbalanced panel. In particular, poverty monitoring data remains low in many countries, especially small and low-income states. Out of the 217 countries that the World Bank Development Indicators report on, only 169 have data available for poverty headcount ratio. As these measures rely on household surveys, there continues to be challenges with the timeliness, frequency, quality, and comparability of the surveys. This may impact research findings, especially as lower-income nations may face more difficulty producing reliable poverty metrics.

Future research could further explore these relationships on a regional scale. Given the dramatic development changes occurring in particular regions, the relationship between poverty and CO2 emissions could be different in different parts of the world. When not controlling for these regional extremes, the coefficient on poverty could have negative bias and overestimate the global relationship between poverty and CO2 emissions. As such, research that accounts for regional patterns may greatly increase broader economic understanding and provide specificity in the implementation of global environmental and economic policy.

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THE LOST DECADE: HOW USE OF MONETARY POLICY SHOULD BE RESTRICTED DURING ECONOMIC BOOMS AND QUICKLY ADOPTED DURING INFLATION AND STAGNATIONS

Zehao Cao

This study employs macroeconomic techniques and research on diverse data sources to examine the appropriate limitations on the use of monetary policies during economic booms and stagnations. The paper will start by analyzing the impacts of monetary policies imposed by the Japanese government from World War II to 1991. Then it also delves into arguments restricting these policies observing the tremendous increase in stock market and real estate prices. This paper hypothesizes that monetary policies should be restricted during economic booms and quickly adopted during inflation and stagnation. The hypothesis will be elaborated through four periods of monetary policies conducted by the Bank of Japan, the "high growth period (1950-1970)", "the Great Inflation", "the emergence of the bubble" and "the burst of the bubble". These four periods present the result of a restricted monetary expansion, a late and insufficient monetary tightening, a monetary expansion with low regulation, and an economic situation where monetary expansion no longer works well, respectively. This paper also posits possible solutions to similar problems which may arise in the future.

I. Historical content

To fully grasp the economic miracle and the Lost Decade, it is important to understand some historical context. The Japanese population was 73.11 million in 1940, after the war the estimated Japanese population decreased to approximately 71 million (Economic and Social Commission for Asia and the Pacific, 1984; Taeuber, 1958). A recent study indicates that Japan lost about 2 million soldiers and about 1 million civilians during the war. As most Japanese soldiers were males, Japan lost a large proportion of its labor force. (Kesternich et al., 2014) Soon after the war, the rebuilding of Japan increased government spending and formed greater flexibility in the money flow. The increase in flexibility in the money flow made Japanese interest rate decrease, incentivizing investors. At the same time, the exchange rate depreciates, and Japanese export became more competitive. Thus, creating the tremendous increase named the Japanese Economic Miracle. The expansion of the manufacturing sector combined with a comparative lower labor costs and higher working hours with western society increased the competitiveness of Japanese manufactured goods and increased exports. Japanese export created a great trade surplus, forcing Japan to open its foreign exchange market and sign an agreement named the Plaza Accord. The signing of this accord effectively appreciated the Yen and the Japanese subsequently invested large amounts in purchasing foreign assets. The capital flow changed from an inflow of 2 billion dollars into an outflow of 132 billion dollars, weakening the restrictions on the window guidance and leading to investment in assets creating asset bubbles. When the bubble burst, the Japanese economy soon fell into a stagnation of more than a decade.

Post-war economy

After the U.S. occupied Japan after 1945, former Japanese soldiers were forced to become laborers rebuilding Japan. Soon after the judgment on the war criminals was over, the Ministry of Finance was in control of the Bank of Japan (BOJ) and imposed expansionary monetary policies targeting greater flexibility on money supply. The BOJ introduced window guidance, an informal monetary policy imposing lending quotas to regulate the volume of credit in the financial sector. Their interest was for a fast economic recovery, which encourages people to lend by decreasing lending requirements. The increase in lending increases the money supply in the market where firms can easily obtain capital. In theory the expansionary monetary policy increases the investment in manufacturing sectors of the economy and spreads its influence on many other factors. Later, Japanese economy proves the theory of expansionary monetary theory.

From the 1950s to the 1970s, the Japanese economy was in a rapid growth trend under the influence of the United States. According to the data from the World Bank, Japan's average annual GDP growth rate from 1961 to 1970 is around 10.44%. The manufacturing industry in Japan was soon revived under the influence of both monetary and fiscal policies as seen in, “the share of secondary industries increasing to 34.0% in 1970.” (Ministry of Health, Labor, and Welfare of Japan) Car manufacturers, electronic product manufacturers and many others increased their production with a monitored window guidance which provides accessible loans. These loans were provided by major banks in Japan after submitting “lending plans every quarter to be approved by the BOJ, and the results were carefully monitored.” (Werner, 2002)

The Japanese economy expanded with an increase in average individuals’ income, thus, the number of cars sold surged. The demand for passenger cars grew rapidly, and the sales volume achieved an average annual growth rate of 32 percent, jumping from 590,000 units in 1965 to

2.37 million in 1970. (Toyota, 2012) Furthermore, the export of Japanese-made cars soon beats "West Germany to become the second-largest car-producing nation in the world." In 1972, Toyota sold its one-millionth car internationally. Japanese car exports continued to grow, and Toyota became the first import automaker to sell more than one million vehicles in the U.S. The increase in exports created about 32 billion net exports in the year of 1984.

Plaza Accord

In the year of 1985, the U.S.- Japan trade deficit reached 122 billion dollars. Likewise, France, Germany, and the United Kingdom also had a trade deficit with Japan. The United States, at the time, was dubbed the debtor nation while Japan had become the second largest economy on the planet. This international demand for Japanese assets put upward pressure on the Yen. This caused the minister of finance of the United States to emphasize that multilateral exchange rate coordination must be implemented. The United States puts pressure on Japan and Germany, countries with large export lead growth and trade surplus for them, to increase domestic consumption rather than exporting goods. Germany refused to employ expansionary monetary policy, but Japan agreed. However, Japanese experts at the time didn't expect the monetary implementations to have such great impact on its economy. The Plaza Accord was signed in New York on September 22, 1985. It was made to gradually appreciate Yen, aiming to solve the great trade deficit between U.S. and Japan.

After the signature of the Plaza Accord, the Japanese Yen appreciated from 260 Yen for 1 Dollar in February 1985, to 155 Yen for 1 Dollar in September 1986. The appreciation of the Yen leads to an increase in higher disposable income for the Japanese people where their buying power increases in the global market. Also, the Nikkei 225 Index grew from 6800 in October 1982 to 19000 in August 1986 meaning there are excessive money besides consumption need for people, these excess money surge into capital markets like stocks. The expanding asset prices also gave confidence to Japanese individuals that the economy would continue to grow. Thus, Japanese individuals started to purchase U.S. exports, and assets in U.S. "The Rockefeller Center, Colombia pictures, and Golf courses, for example were bought using Japanese capital. In the year of 1986, 75% of the U.S. Treasury was bought by Japanese money." (Princes of Yen, Michael Oswald, 2014) The investment in U.S. real estate and U.S. Treasuries increases Japan's capital outflow. Though capital outflow is high, the money lent from banks continually injects into capital market causing a continual rise in the stock market.

By the late 1980s, Japan's real estate prices rose with a positive expectation of the future and an overreaction to the appreciation. With an increase in lending with window guidance and a lower discount rate, though the Japanese Yen appreciation caused capital outflow, import prices were still relatively low and the remaining money flowed into the stock market and real estate market. The increase in real estate prices breaks down into all the economic sectors. Rent and labor costs increase, thus, increasing the production costs, causing firms to prefer manufacturing facilities in China where the cost is lower.

With an overreaction to the appreciation of the Yen, the economic bubble was created. After the burst of the bubble, the Japanese economy entered a prolonged period of stagnation, lasting for decades. This period, characterized by an annual growth rate of GDP lower than 2-3%, is commonly referred to as the Lost Decade.

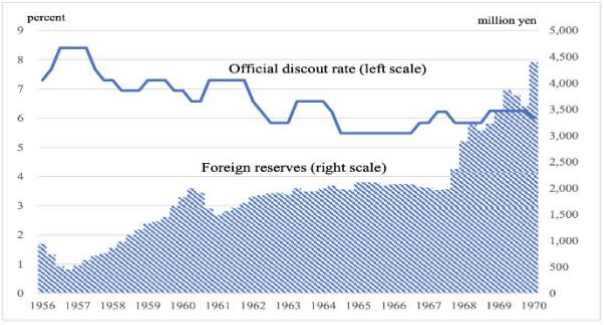
II. Monetary policies

With the historical context discussed, it is obvious that monetary policy played a significant role in both the economic miracle and the Lost Decade. Lost Decade to some extent was due to the excess use of monetary policy without considering its side effect. It didn't recover in a short amount of time due to limited expansionary policies. Thus, it follows that monetary policies should be restricted during economic booms and quickly adopted during inflations and stagnation.

High Economic Growth (1950-1970)

From 1950-1970 Japan was in a state of high economic growth, where its average annual growth rate was around 10-15 percent, whereas other developed nations only have a 6-10 percent GDP growth rate. There were different monetary policies introduced to boost the economy after World War II. The BOJ injected short-term liquidity by keeping the domestic interest rate as low as possible for industrial firms producing cars and electronic devices. They also inserted capital into the economy while maintaining a fixed exchange rate with the Dollar. During the high growth period, two common monetary tools adopted by The Bank of Japan were the ODR (official discount rate) and the window guidance. The official discount rate is the interest rate charged on local commercial banks which affects the overall interest rate. The BOJ used window guidance as a complementary tool to ODR. Using the window guidance policy, BOJ applied moral persuasion on private banks regarding the volume of their lending to customers. During the time the central bank applied moral persuasion, the BOJ incentivize local banks to lend to customers who want to invest in major industries in Japan. During the high economic growth period, the financial market was heavily regulated. The discount rate increases when the foreign reserve is low and decreases when foreign reserve is high.

Figure 1-Official discount rate and foreign reserves



Sources: Source: Bank of Japan, *Economic Statistics Annual*, annual editions

The lending proportion in the reserves starts to increase after the monetary policies are allocated. According to Figure 2, the average loan percentage in city banks and local banks increased from 5% in 1950-1955 to 20% in 1956-1960. Most of the loans go into the manufacturing industry improving the industrial sector of the Japanese economy. The lending is accompanied by a regulatory measure where banks require their customers to retain a portion of lending as compulsory deposits. The ratio of the compulsory deposits is frequently changed to manipulate the lending interest rate.

Figure 2- From The Bank of Japan

CHANGES IN THE NUMBER OF BRANCH OFFICES, DEPOSITS, AND LOANS
(ANNUAL AVERAGE)

(%)

	City Banks			Local Banks			Thrifts[a]		
	Branch	Deposits	Loans	Branch	Deposits	Loans	Branch	Deposits	Loans
1951–55	−0.1[b]	18.8[c]	6.2[c]	4.4	14.5[c]	11.7[c]	8.4	19.4[c]	16.6[c]
1956–60	−0.4	18.5	20.5	−0.1	20.0	20.0	4.0	24.3	24.5
1961–65	3.1	17.7	18.3	1.9	19.5	19.3	5.6	26.2	24.9
1966–70	1.1[d]	14.3	14.9	1.2[d]	15.4	16.4	3.1[d]	17.8	19.1
1971–75	0.9	17.2	17.2	2.7	18.3	18.0	3.3	20.3	18.9
1976–80	1.2	10.4	8.4	2.6	12.1	10.4	3.3	11.8	11.2

The supply of loans to manufacturing facilities in Japan also came from capital inflow. In the first half of the 1960s, Japan had net capital inflows. They were invested in the newborn Japanese economy. In 1964, however, Japan joined the Organization of Economic Cooperation and Development (OECD), marking its return to the international financial market. To join, Japan was asked to liberalize their financial market where they are required to remove all the constraints on current account transactions and reduce the constraints on capital account transactions. By the late 1960s, Japan no longer bounds its monetary policies with its balance of payments and its current account was in continuous surpluses due to an increase in their export. During the "high economic growth" period, the BOJ successfully operated monetary policy with sufficient regulations. Therefore, Japan quickly recovered from the war and gradually became a major player in the international financial market. Regulations such as compulsory deposits prevent monetary policies getting out of control, which makes them effective.

The Great Inflation

The original international monetary system is the Bretton Woods agreement, which is to base the price of Dollar at the price of gold and other currencies pegged to dollar value. The collapse of the Bretton-Woods agreement brought a significant impact on the Japanese Yen as it was previously allowed to stay at a fixed exchange rate with a dollar where 1 Dollar equals 357 Yen. The Japanese Yen started to appreciate from 357 yen to 1 dollar in August 1971 to 300 yen to 1 dollar in July 1972 (Shown in Figure 3, the exchange rate of Dollar to Yen). The appreciation of Yen, however, made Japanese export-dependent industries vulnerable. Thus, Monetary easing was implemented. This easing is, nevertheless, considered a mistake afterward as the easing brought the inflation rate to 12% in 1973 and the CPI from 3.9% in Sep 1972 to 24.9% in Feb 1974. The ODR, Japan's major monetary tool, was not implemented until April 1973 to 5%; the rise in ODR was proven to be insufficient to curb the rising inflation. Meanwhile, the oil crisis of 1974 tripled the price of imported oil in Japan, further hindering the fight against inflation.

The increase in CPI should have been predicted by the BOJ long before the inflation got out of control. As shown in Table 1, the increase in CPI index starts to accelerate starting from Sep 1972. At the same time, WPI (wholesale price index) inflation started to increase.

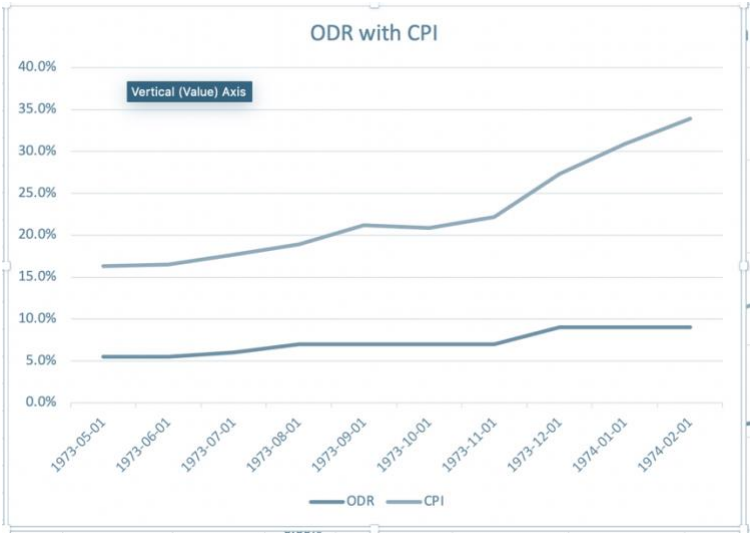
these indicators had presented a potential risk of inflation in the future, the BOJ could have quickly adjusted the ODR and adopted a monetary tightening policy to focus on eliminating the possible risk of higher expectations of inflation.

Table 1- Source: The Bank of Japan

Time	CPI	WPI inflation
Sep-72	3.90%	2.2%
Oct-72	4.40%	3.2%
Nov-72	5.10%	5.0%
Dec-72	5.70%	6.3%
Jan-73	6.70%	7.6%
Feb-73	7.00%	9.3%
Mar-73	8.70%	11.6%
Apr-73	9.40%	11.8%

However, the BOJ did not react in time as shown in Figure 4 where the increase in ODR didn't successfully suppress inflation. Thus, the higher expectations of inflation by the public subsequently put upward pressure on wages. This wage increase is reflected in the production cost and therefore increases the price of goods and services. As such, the inflation did not stop with the lack of reactions by the BOJ.

Figure 4-Graph made with data from The Bank of Japan



After the first increase on ODR in Apr 1973, the interest rate continued to increase while the Yen continued to appreciate from 300 Yen to 1 Dollar in February 1973 to 260 Yen to 1 Dollar in October 1973, as shown in Figure 3. The appreciation of Yen caused a decrease in exports meaning the export-based economy was harmed by the appreciation. The decrease in exports decreased GDP, and, for the first time since 1946, the Japanese economy faced a negative

growth. From 1973 to 1974, the Japanese economy faced a stagflation: the GDP growth rate was -1.23% in 1974 and the inflation in 1974 was 23.22%.

Figure 3-Exchange rate 1 Dollar to Japanese Yen over time

During the Great Inflation period, the BOJ failed to impose monetary tightening on time while consumers expected higher inflation. The insufficient monetary tightening after the oil crisis pushed inflation to 23.22% in 1974. The inflation and the appreciation brought the stagflation in 1974. Therefore, the hypothesis that monetary policies should be adopted quickly when experiencing inflation holds.

The Emergence of the Bubble

After the great inflation in 1974, the Japanese economy recovered to a lower level of growth. The annual growth rate dropped from 10% in 1950-1970 to 5% in the late 1970s. The increasing Japanese manufacturing power drove Japan's trade surplus with Western countries high. In the year of 1985, the U.S.- Japan trade deficit reached 122 billion dollars. This caused tensions in the international financial market, especially with Japan and the United States. To prevent potential trade conflicts, G5 countries (Japan, the U.S., West Germany, France, and the UK) got together to resolve the trade imbalance. The Plaza Accord, the agreement reached at this summit, focused on solving the trade deficit and budget deficit faced by the U.S.

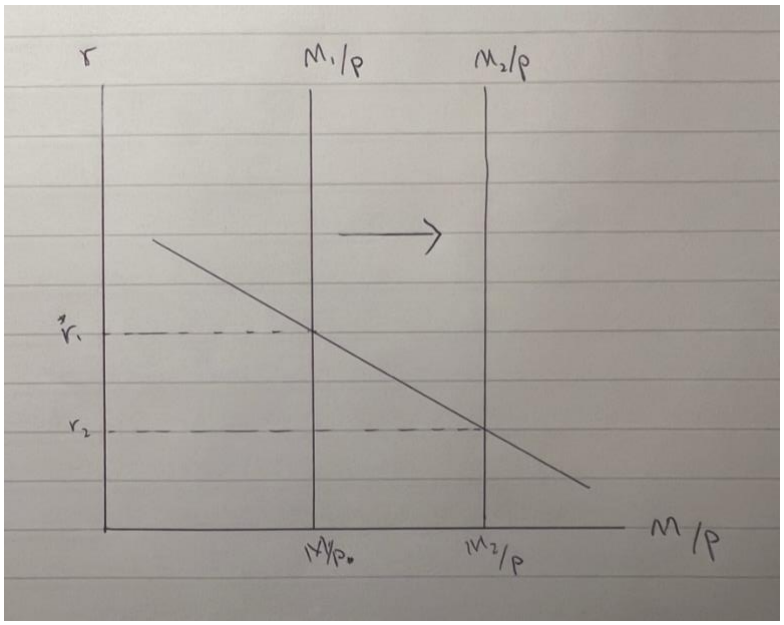
The Plaza Accord made Japanese Yen appreciate rapidly. The BOJ believed that the sudden appreciation of the Yen would harm the exporting companies and therefore harm the economy similar to what happened in 1974. Seemingly it did as Japan's export growth dropped from 2.4% in 1985 to -4.8% in 1986. The BOJ reacted quickly to operate an expansionary

monetary policy to increase domestic purchases of goods and services aiming to bring Japan into a domestic demand-promoted economy.

"The official discount rate, which had been 5% since October 1983, was lowered in steps starting in January 1986, and in February 1987 it became 2.5%, the lowest level ever. This loosening of monetary policy was seen as necessary to cope with the sudden appreciation of the yen in the wake of the Plaza Accord of September 1985." (Noguchi, 1994) As mentioned before, window guidance was always a complementary measure with ODR. The window guidance policy was also strictly regulated from the 1950s to the 1970s. However, the restriction on window guidance soon fell apart due stipulations of the Plaza Accord. This forced "the Bank of Japan to significantly increase the window guidance loan quotas. Average yearly loan growth quotas were nearly 15% in the late 1980s." (Oswald, 2014)

With a decrease in ODR, the interest rate charged to the commercial banks by the central bank decreases. Therefore, commercial banks tend to, instead, lend to the public. As mentioned before, with the increase in loan quotas, the money supply in the market increases. Presented in the diagram in Figure 5 is the shift of the real money balance curve to the right.

Figure 5-Loanable funds market



The increase in money supply decreases real interest rate which creates excess liquidity, where people's opportunity cost of holding money decreases. At the time, Japanese industry was in full production which made the excess liquidity go into speculation instead of production. The excess liquidity created a bubble in the stock market and asset market instead of bringing growth to the manufacturing sector. While Japan held the world's lowest interest rate at the time, its interest rate spread meaning the difference in interest rate compared to the U.S. is over 300 base points. People tend to lend and invest in foreign treasuries to benefit from the interest rate spread. The stock market at the time, indicated by the Nikkei 225 index, increased from around 7000 in

the early 1980s to 38800 in the late 1980s. This is a near 550% growth in 8 years as shown in Figure 6.

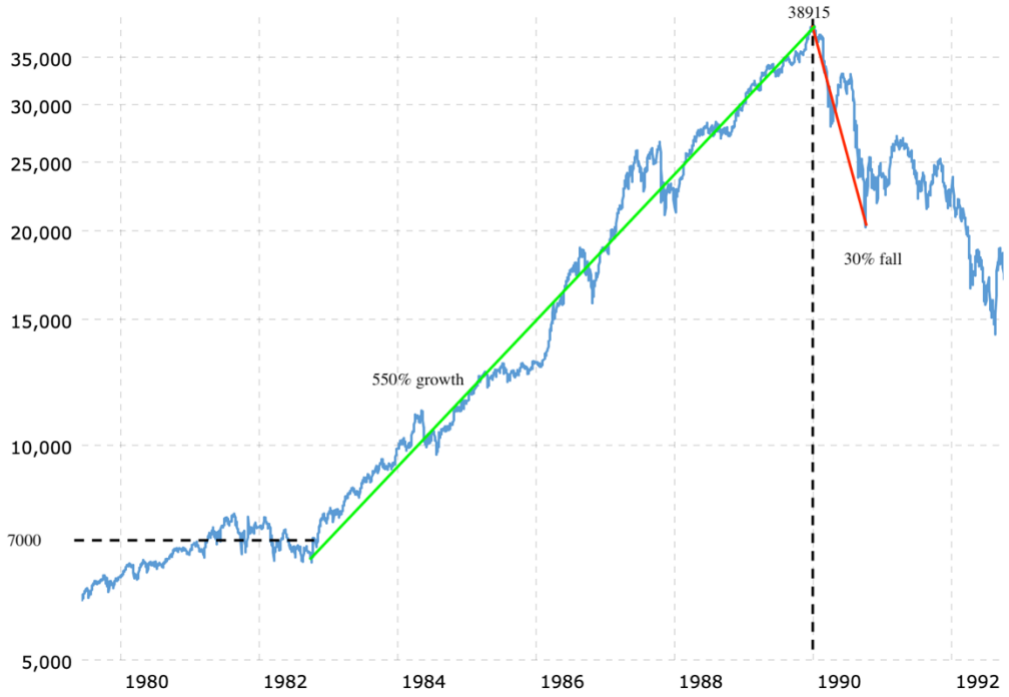


Figure 6-Data from Nikkei 225 Index, trend line marked based on the data

The asset prices of gardens near the Empirical Palace in Tokyo were nearly worth the entire state of California. The value of land in Japan was four times the value of land in the U.S. while Japan is only 1/26 the size of the U.S. For individuals, the National and Regional House Price Indices increased from 118.7 in 1986 to 226.5 in 1990 in Tokyo (OECD statistic). The increase in the speculating market became unbelievable and many leading manufacturers like Nissan made more profit through speculative investment than through manufacturing cars. These increases in the stock market should be indicators of a good economy. However, the average annual growth rate of the Japanese stock market was 50% while the real GDP of Japan only grew 4% between 1985-1989.

This bubble was created with the misuse of the expansionary monetary policy. Like the overreaction to the oil crises back in 1974, the BOJ overreacted to the appreciation of Yen. The expansionary monetary policy breaks the chain restricting the window guidance, and the banking sector promotes people to loan. The excess money supply didn't bring a boost in the inflation rate but created a bubble economy. At the time, the growth in the Japanese economy was believed to be normal, and people believed that Japan would continue its expansion just like in the 1960s. This, in fact, is not what happened. Hence, the excess monetary easing should be restricted observing such an increase in asset prices and stock prices.

The Burst of the Bubble and The Lost Decade

At the end of 1989, the governor of the BOJ announced that, "since the previous policy of monetary easing has caused a land price rising problem, real estate related lending will be restricted." The sudden tightening of monetary policies finally burst the asset bubble in Japan. The discount rate first increased from 2.5% to 3.25% in 1989; it was subsequently raised step by step over 15 months to 6% in August 1990. The money supply growth rate fell from 12% in 1989 to 2.3% in 1991. At the same time, the BOJ strictly controlled the window guidance policy complementing the monetary tightening and the increase in the ODR. The BOJ even set a quota on real estate related loans.

Table 2-https://stats.oecd.org/Index.aspx?QueryId=98836#

	Annual						
	1989	1990	1991	1992	1993	1994	1995
Tokyo (JPN)	191.5	226.5	206.9	174.3	158.4	156.6	147.0
Aichi (JPN)	123.3	151.9	165.3	154.3	146.9	143.2	139.2
Osaka (JPN)	233.5	316.3	236.6	205.8	195.5	197.2	187.4

With the implementation of the strict monetary tightening, stock prices and asset prices fell at the same time. Shown in Figure 6, the Nikkei 225 index fell by 30% in 1990. By the time of August 1992, the stock price had fallen by 50%, from 38800, in 1989, to 14800. The National and Regional House Price Indices also fell from 226.5 in 1990 to 158.4 in 1993 in Tokyo. The fall in asset prices is the same with the major cities in Japan, cities like Osaka and Aichi both peak in 1990 and fall afterwards as detailed in Table 2.

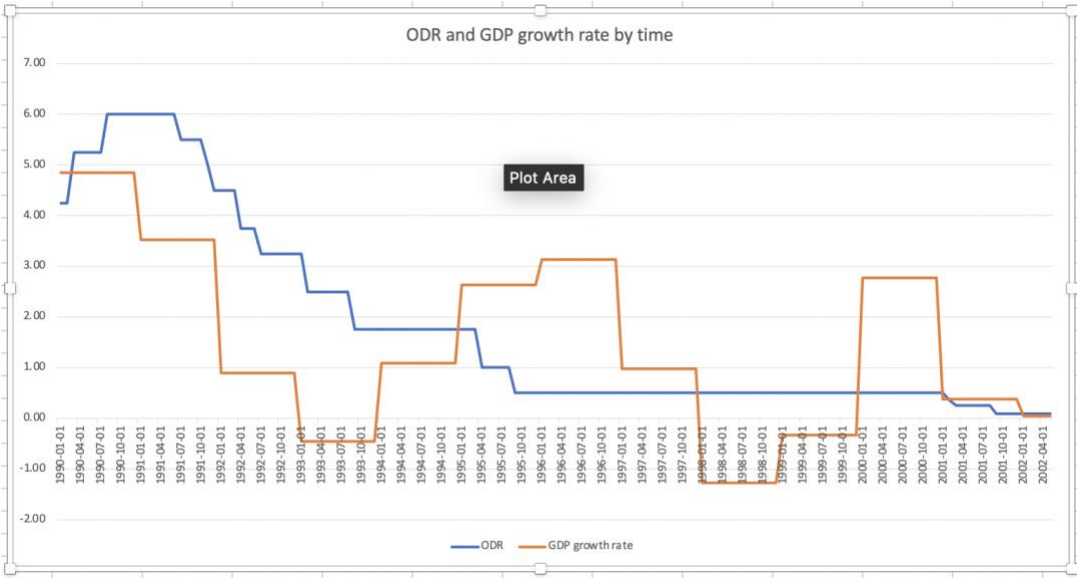
The major reason for the collapse of the economy is the sudden tightening of the monetary policy. The tightening of monetary policy was inevitable for Japan. If the BOJ does not tighten the monetary policy in a short amount of time, the bubble will continue to grow. A larger economic bubble would have just worsened future conditions. One of the possible ways to soft-land the economic bubble is through manipulation of the currency. By depreciating the Japanese currency, their production could become competitive again. However, the depreciation of the Yen would violate the terms of the Plaza Accord; so, the only way to end the bubble was through a sharp tightening of the monetary policies.

This sudden burst of the bubble brought the Japanese economy into stagnation. This period, characterized by an annual growth rate of GDP lower than 2-3%, a prolonged deflation commonly referred to as the Lost Decade. Starting from 1991 to 2000 there was a continued increase in unemployment of over 5 million people. Although a monetary expansion policy was imposed by the BOJ starting in 1991, the unemployment problem remains, even today. Japan's GDP growth rate remained lower than 2-3% from 1992 and the inflation rate in Japan was lower than 2% starting from 1992, and even below zero from 1998 to 2005.

To get out of the stagnation and prolonged deflation, the Ministry of Finance put pressure on the BOJ to lower the interest rate until the official rate reached 0.1%. Economic recovery was

expected when economists believed that low interest rates would stimulate growth. However, as shown in Figure 7 with the comparison of the ODR with the GDP growth rate, the reality didn't reflect the expected outcome. The cause of the low growth rate may be the consumption habits of Japanese households. People tend to save more in Asian countries rather than consuming goods with credit. (Ye, et al. 2020) Also, the Japanese government placed stimulus packages using the government budget. However, these packages came from government bonds, which means the government was simply taking money out of the economy simply to inject it again.

Figure 7-Graph made with data from The Bank of Japan



III. The Zero Lower Bound

The BOJ continued to lower the ODR aiming to stimulate the economy during the Lost Decade, through 4 years starting in 1991 the BOJ lowered the ODR from 6% to 0.5%. Here, the interest rate hits near the Zero Lower Bound (ZLB). As shown in Figure 7, the decrease in the ODR did not reflect in the GDP growth rate. This can be explained through the equation for real interest rate where it is set equal to nominal interest rate minus the expected inflation rate. When a lower nominal interest rate exceeds the lower in the expectation of inflation, the real interest rate will fall. Otherwise, even if the nominal interest rate falls to zero, as it did during 1991-1995 in Japan, the real interest rate may still be high.

When the economy is in a state where the interest rate is already zero, any increase in the money supply will not expand the economy. The opportunity cost of holding money reached its lowest level, there is no difference for people to hold money or to save it in the bank. In this case increase in the money supply no longer give incentives for people to lend.

The Bank of Japan expanded its money supply, but the impact was gradual, with interest rates reaching the zero lower bound over a period of four years. This timeline contrasts with the rapid responses seen during the 2008 financial crisis in the U.S. and the Federal Reserve's swift interest rate cuts during the COVID-19 crisis. The slower pace of the BOJ's monetary policy implementation led to a lack of confidence among the public in the effectiveness of the bank's

actions. As a result, the policy was less impactful than it could have been had it been implemented more swiftly. In 2008, the Fed reached ZLB in 2 years, and in COVID-19 interest rate became 0% within weeks. These monetary easing policies are quickly adopted and gave positive examples of solving future similar problems, and thus have even been used in similar situations by China and the U.S. Japan, nonetheless, was, at the time, inexperienced when it came to solving a stagnation problem.

IV. Conclusion

The economic change in Japan over the course of "high growth period (1950-1970)", "the Great Inflation", "the emergence of the bubble" and "the burst of the bubble" left many lessons for other countries around the globe. The hypothesis that monetary should be restricted during economic booms and quickly adopted during inflation and stagnation is, therefore, evident in the developments of Japanese economy. In the high growth period, the implementation of monetary policies was restricted and carefully used. In the great inflation, monetary expansion was hastily implemented due to the over expectation of the global economy. Also, monetary tightening was not implemented quick enough when significant signs of inflation appeared. The emergence of the bubble proves the expanding monetary policy should be restricted and more carefully implemented. Although, other external factors certainly contributed to the emergence of the bubble, the overreaction through monetary policies is still significant. The Lost Decade was due to an insufficient reaction of the BOJ as the ODR could have decreased faster by monetary easing and purchase of the bad debts in commercial banks.

The hard landing of Japanese economy from the asset and stock market bubble should be other lesson learned. The fall in asset prices, the bad debts in commercial banks, the unemployment, and the bankruptcy of many Japanese firms brought prolonged shadow over Japanese economy. The negative impact is still there now, even the burst of the bubble already passed 30 years.

Developing countries like China should gain experience from Japan when facing the asset bubble. Chinese economy is using a soft landing for the asset bubble in the cities in China. However, difference in social and political status made differences between Japan and China. With a market economy, Japan is not able to introduce policies like currency control and similar planned economy used policies.

V. Reflections On The Paper

The further research on this paper should be focusing on the comparison between other countries facing similar issues. The further research should be developed based on observing difference between Chinese soft landing and Japanese hard landing. Topics can also include a detailed data analysis comparing the outcome of monetary policies in U.S. during 2008 financial crises and COVID-19 crises. However, this paper's outcome may only apply to a specific country as the demography, historical background, and natural resource limitations may vary the application of the hypothesis concluded. The complexity in managing monetary policies in a country largely depends on social background described above. Furthermore, monetary policy is not the only way managing the economy in a country, differences between fiscal policies could affect the outcome of the monetary policy.

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THE NECESSITY OF HUMAN INVENTIVENESS: EXAMINING THE RELATIONSHIP BETWEEN ARTIFICIAL INTELLIGENCE AND TECHNOLOGICAL INNOVATION

Marko Radulovic

Recent advances made in the field of artificial intelligence (AI) have sparked debate regarding whether such systems are truly capable of innovating autonomously. This study investigates how AI adoption, as measured by the number of scholarly publications on the topic, affects technological innovation, as measured by the number of annual patent applications. Using a panel dataset encompassing information on 195 countries across the period from 2011-2020, my results suggest that there is a statistically significant negative and diminishing relationship between AI adoption and invention. This result is robust to the inclusion of country and time fixed effects and continues to hold when R&D expenditures and the number of R&D researchers are held constant. Countries with low levels of AI adoption are losing more of their capacity for invention than countries where AI is already well-established and thoroughly researched. That said, this model does account for just 8.6% of the variation in patent applications and therefore suggests that scholarly publications on AI may be a poor predictor of the number of patent-eligible inventions a country produces. Indeed, AI systems may serve only as an aid to human ingenuity as opposed to an autonomous force posing a threat to contemporary society.

I.Introduction

The ever-evolving field of technology is experiencing tremendous growth due to the increasingly widespread implementation of artificial intelligence models and algorithms in scientific contexts. AI adoption can reduce human error, automate repetitive processes, and handle complex datasets, thereby aiding in the development of patentable discoveries (Maheshwari, 2023). The field of molecular biology, for example, was transformed with the development of AI models capable of accurately predicting the 3D structure of almost all proteins. Such advances aid scientists in the design of new drugs and can lead to the development of novel therapeutics eligible for patent protection (Callaway, 2022).

Recently, researchers have spent significant time exploring whether AI – more than being able to assist with important but monotonous tasks alone – might possess inventive capabilities that would allow it to produce completely novel concepts and products. Findings drawn from current literature indicate that AI systems currently lack their own autonomy in innovating largely because of their substantial dependence on human input (Kim, 2020; George & Walsh, 2022). Despite this, a U.S. Federal Court has already ruled that AI systems cannot patent inventions, even if they were independently produced, because they are not human beings (Vincent, 2022). Nevertheless, the possibility of AI abilities surpassing human intellectual capacities has prompted a more careful investigation of how AI adoption might affect invention. Specific questions have arisen regarding the uniqueness of certain features of human intelligence and whether traits like creativity and innovation might be replicated in machines.

My research utilizes a panel dataset consisting of information spanning 195 countries between the years 2011-2020 to explore the relationship between AI adoption, measured here as the number of scholarly publications on AI (per one million persons), and technological invention, measured here as the number of patent applications (per one million persons). Along with this, I investigate the effect of other variables hypothesized to contribute to variation in the number of patent applications and to determine whether these factors contribute to bias in the predictive effects of AI adoption. In line with existing literature, I expect the relationship between scholarly publications on AI and patent applications to be negative given AI systems' current failure to demonstrate an autonomous capacity for discovery. Moreover, it is expected that identification of this relationship will be contingent on controlling for the amount of research and development (R&D) expenditures in a country given that the nations who allocate a larger proportion of their GDP to R&D are expected to file a greater number of patent applications in general in addition to producing a greater number of research articles on AI.

The empirical model estimated here demonstrates a statistically significant negative and diminishing relationship between scholarly publications on AI and the number of patent applications. The use of a quadratic fit predicts a turning point in the key relationship between AI adoption and invention at around 144 articles on AI (per one million persons) – a point below which nearly 90% of observations lie. In addition, the variables for R&D expenditure and the number of R&D researchers are shown to have statistically significant coefficients implying that they each represent an important factor affecting patent research.

Altogether, my results suggest that following a greater utilization of AI, countries with low levels of AI adoption will lose more of their capacity for invention than will countries where AI research is already well-established. I note here that my empirical model accounts for just 8.6% of the variation in patent applications. This suggests that the annual number of articles published on artificial intelligence cannot alone predict a given country's aptitude for the

production of patentable inventions. It is strongly suggested that human creativity is necessary for the proliferation of new inventions – a thought that runs directly contrary to the widely held belief that AI already possesses abilities surpassing human cognition across all realms of knowledge.

II. Literature Review

Recent advances in the field of AI, especially rapid improvements in the ability to make predictions using simulated neural networks (SNNs), have sparked optimism for the acceleration of scientific breakthroughs. SNN-based machines can alter the knowledge production function in two key dimensions: (1) the "search" dimension in which AI most certainly outperforms humans in being able to identify complex and subtle patterns in high-dimensional data and (2) the "discovery" dimension, or the ability to develop insights and produce findings given certain pre-existing elements of knowledge, something that can result in novel technological inventions (Bianchini, Müller, & Pelletier, 2022). The extent to which AI can contribute to "discovery" is currently the subject of fierce and extended debate with some researchers arguing that AI-generated inventions are fundamentally reliant on human instruction and others suggesting that increasing the application of AI itself would not increase the output of patent-eligible technologies (Kim, 2020). Analyses conducted on DABUS, an AI system credited with having conceived of two inventions, have reaffirmed the importance of human inputs (George & Walsh, 2022).

Some studies present AI as an emerging general method of invention with the potential to have major impacts on scientific discoveries; others, however, emphasize a large degree of uncertainty associated with their potential impact (Bianchini, Müller, & Pelletier, 2022). There is an overall consensus that AI aids in the computational problem-solving required for many inventions, yet there is a lack of evidence supporting its autonomy in discovery (Kim, 2020). These findings suggest that higher levels of AI adoption may not necessarily increase a country's capacity for technological invention given the vital role that humans undoubtedly continue to play. Accounting for some of the multitude of other factors that contribute to a country's number of annual patent applications, AI adoption is theorized to be a poor predictor of technological invention due to its strong and sustained dependence on underlying human ingenuity.

III. Data and Descriptive Statistics

This study employs panel data at the country level from the years between 2011-2020 to identify a relationship between AI adoption, measured as the number of scholarly articles published on AI, and technological invention, measured as the number of patent applications. The dataset includes observations for the two main variables in addition to four control variables. There are a total of 195 different countries and 5,877 observations overall.

Information about the number of articles published on AI is obtained from the *Center for Security and Emerging Technology* which measures the annual number of scholarly publications (in English and Chinese) related to the development and application of AI including that in journal articles, conference papers, books, and theses (per one million persons). Patent data is sourced from the *World Bank* and represents the annual number of patent applications per one million persons. To prevent statistical distortions, a group of outliers with an annual number of patents exceeding 1,000 per one million persons were removed from the dataset. As a result, all

data points associated with Japan and a majority of those associated with South Korea were subsequently excluded. Data on the total number of articles published in scientific or technical journals per one million persons is taken from the *World Bank*. Information on both R&D spending as a share of GDP and the number of R&D researchers per one million persons is obtained from *UNESCO*. Lastly, data regarding the share of the population with tertiary education is the percentage of people aged 25 to 65 years who have either completed or partially completed tertiary education and is acquired from *Our World In Data*.

Table 1-Variable Descriptions

patents	Annual Patent Applications per 1 Million People
aiarticles	Scholarly Publications on Artificial Intelligence (per 1 million persons)
totalarticles	Articles Published in Scientific and Technical Journals (per 1 million persons)
rdexp	Research & Development Expenditure as a Share of GDP (%)
researchers	Number of Researchers in Research & Development (per 1 million persons)
tertiaryedu	Share of the Population with Completed Tertiary Education (%)
aiart_sq	Squared Term: aiarticles^2
aiart_rdexp	Interaction Term: aiarticles * rdexp

Table 2-Summary Statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
aiarticles	1,942	47.26	74.85	0.0317	485.7
patents	3,663	81.27	132.9	0.0103	902.6
totalarticles	3,666	280.1	508.0	0	2,704
rdexp	2,094	0.887	0.892	0.00544	5.436
researchers	1,619	1,943	1,887	5.912	8,007
tertiaryedu	1,027	32.90	13.25	5.597	69.58

IV. Empirical Model

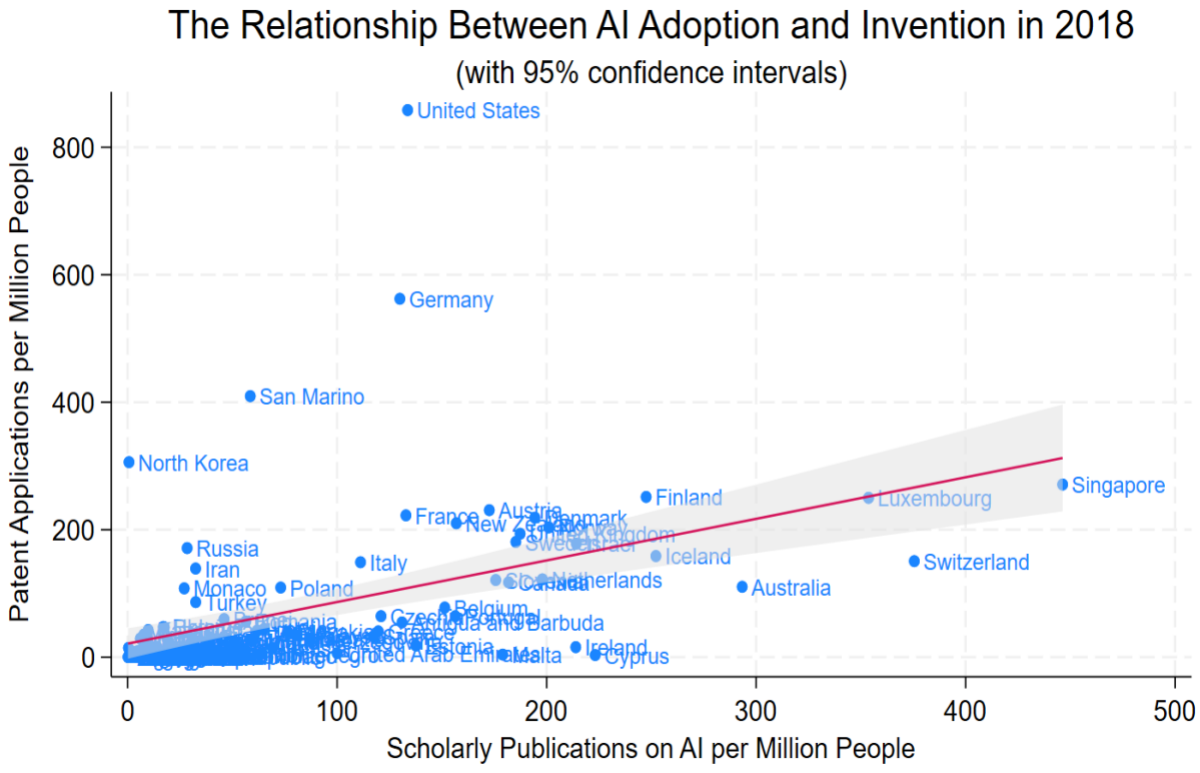
The estimated model defines the number of patent applications as a function of the number of articles published on AI, R&D expenditures, and the number of R&D researchers with country- and time-fixed effects.

$$\boldsymbol{patents_{it}} = \boldsymbol{\beta_1 aiarticles_{it} + \beta_2 aiarticles_{it}^2 + \beta_3 rdexp_{it} + \beta_4 researchers_{it} + a_i + \lambda_t + u_{it}}$$

Within this model, and holding country *i* and time *t* constant, *patents* is a continuous dependent variable and represents the number of patent applications in country *i* at time *t*, while *aiarticles* is the main independent variable likewise corresponding to each country-year pair. The model specifies a quadratic relationship where a positive coefficient is associated with the squared term and a negative coefficient is associated with the main variable. This suggests that the relationship between AI adoption and technological invention is negative and diminishing. The variables for R&D expenditure and the number of R&D researchers are included as controls.

Figure 1 depicts a scatterplot between the number of patent applications and the number of scholarly publications on AI in 2018 for a total of 119 countries. The relationship between the two variables is positive, contradicting the results suggested by the empirical model, likely as a result of unaccounted for differences in R&D expenditure between countries. It is theorized here that countries with a greater proportion of their GDP allocated to R&D publish a greater number of articles on AI but also submit more patent applications more generally when compared with countries that have lower shares of R&D expenditures, justifying this positive trend.

Figure 1-Scatterplot of Patent Applications and Scholarly Publications on AI, 2018



V. Results

Table 3-Regression Results

VARIABLES	(1) patents	(2) patents	(3) patents	(4) patents	(5) patents	(6) patents
aiarticles	0.652***	0.0354	0.00429	0.186	-0.564	-0.390**
	(0.0983)	(0.113)	(0.109)	(0.265)	(0.384)	(0.196)
rdexp		179.3***	72.47*	37.81**	37.37*	74.44*
		(23.14)	(39.18)	(16.86)	(18.58)	(39.69)
researchers		-0.0315***	-0.0309**	-0.0118*	-0.00877	-0.0295*
		(0.0100)	(0.0150)	(0.00645)	(0.00546)	(0.0149)
totalarticles				0.00225	0.0156	
				(0.0296)	(0.0306)	
tertiaryedu				0.805	0.921	
				(1.171)	(1.137)	
aiart_sq					0.00157*	0.000829*
					(0.000900)	(0.000433)
Constant	21.35***	-26.62***	86.24***	87.64*	105.7**	97.44***
	(7.263)	(4.756)	(23.67)	(48.55)	(45.93)	(23.01)
Observations	116	667	667	304	304	667
Adjusted R^2	0.241	0.503	0.076	0.148	0.185	0.086
Country FE	NO	NO	YES	YES	YES	YES
Year FE	NO	NO	YES	YES	YES	YES
Countries			98	44	44	98

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A simple linear regression of the number of patent applications on the number of scholarly articles published on AI for the year 2018 (Model 1) reflects a statistically significant and positive effect arising from the number of AI articles on the number of patent applications. The coefficient on my main variable implies that, in 2018, the publication of a scholarly article on AI is expected to result in a 0.652 patent application increase in that year.

Model (2) controls for both R&D expenditure and the number of R&D researchers – two key factors expected to have an effect on both AI application and patent research. Although both variables display statistical significance at the 1% level, the coefficient on my main variable subsequently becomes insignificant. I proceed to perform two joint F-tests between each control variable and the main variable and find that they are both jointly significant and therefore require further examination.

The remainder of the models estimated in this analysis are fixed effects models that

control for time and variant factors that may vary across countries and factors that affect patents across time but do not vary across countries. Model (3) utilizes country- and time-fixed effects while controlling for R&D expenditure and the number of R&D researchers. Although the coefficient on the main variable in this model remains insignificant, variables *rdexp* and *researchers* are statistically significant at the 10% and 5% significance levels, respectively. These initial and simple models suggest that R&D expenditure and the number of R&D researchers are associated with variation in the number of patent applications and are thus sustained in all forthcoming models constructed in this analysis due to their predictive effects.

Despite the inclusion of further control variables in Model (4), like the number of scholarly articles published per one million persons and the share of people with completed tertiary education, the coefficient on the main variable remains insignificant. Additionally, the two control variables themselves are not statistically significant. However, the two original control variables, *rdexp* and *researchers*, remain statistically significant at the 5% and 10% significance levels, respectively. These results further emphasize the importance the human workforce plays in giving rise to technological inventions as opposed to artificial intelligence alone. Moreover, they also suggest that the relationship between the number of scholarly articles published on AI and the number of patents applied for may not actually be linear.

Model (5) tests a quadratic estimation with the addition of a squared term *aiart_sq* which displays a positive and statistically significant coefficient at the 10% level. In this model specification, the principal variable of interest now displays a negative, yet statistically insignificant coefficient of -0.564. Taken together, these results suggest that the relationship between the number of scholarly articles published on AI and the number of patents applied for is negative and diminishing up until a turning point at 180 articles on AI per one million persons, a range to which 92.8% of observations belong. The model itself accounts for 18.5% of the variation in the number of patents applied for.

Lastly, I estimate Model (6) by omitting the two least significant variables – the total number of scholarly articles published more generally and the share of people who report completed tertiary education. In this model, the coefficients on all the variables are statistically significant. Similar to Model (4), the coefficient on the main variable is negative and the coefficient on the squared term is positive. Again, the model outlines a negative but diminishing relationship between the number of scholarly articles published on AI and the number of patent applications. The turning point falls from 180 articles to 144 articles (on AI per one million persons) with 88.8% of observations now lying in this range. This model accounts for just 8.6% of the variation in the number of patent applications, suggesting that the number of scholarly publications on AI are a poor predictor of the number of patent-eligible inventions a country produces.

VI. Conclusion

The results outlined in this study suggest that publishing a greater number of scholarly articles on AI is associated with an expected decrease in the number of patent applications being filed, especially in countries where AI adoption is already low. This relationship is in line with my initial hypothesis drawn from existing literature but runs contrary to that presented in Figure

1. The clear dependence of AI adoption on R&D expenditure supports these findings. Countries with poor AI utilization must spend more money to attain foundational knowledge in AI before researching it, taking away from their spending on potential technological inventions. Such a relationship implies that education and training in less developed countries require greater investments, as well as R&D funding, to equip the workforce with skills complementary to AI technologies.

Furthermore, my work contributes to the ongoing debate surrounding AI autonomy and provides support for the argument that AI adoption alone does not explain the variation in levels of technological innovations. As mentioned previously, the final model accounts for just 8.6% of the variation in the number of patent applications filed. The creativity of people therefore cannot be ruled out as a driving force behind scientific breakthroughs and technological innovations.

VII. Limitations and Future Research

Given that developments in artificial intelligence are a relatively new phenomenon, one of the most critical limitations of this study is the temporal constraint of the dataset. Information outlining the number of articles written on AI has only existed since 2011 and for a limited number of countries. This poses significant challenges in attempts to capture longer-term dynamics and the evolution of AI-related phenomena. Additionally, variable lags and lead times were not used here and therefore represent a potential limitation of this research. AI systems cannot be employed instantaneously and are not ready for immediate use even if they do possess important inventive capabilities. The longer and frequently substantial periods of time required for training artificial intelligence only echo this further.

In future research, advances in AI must be closely monitored over time due to the rapidly evolving nature of the field and its growing integration into a variety of different sectors. Potential connections between artificial intelligence and technological invention only stand to become more complex and subtle. Additionally, this research does not consider the possibility that AI may have different impacts in specific industries or sectors. Continued analysis of developments in the field will be critical for policymakers, businesses, and researchers going forward. This will best ensure the adoption of strategies that promote a harmonious coexistence between all that AI technologies stand to offer and the human-driven inventive process.

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THE PHILLIPS CURVE: ECONOMIC CERTAINTY OR IN NEED OF ADJUSTMENT?

Ashwin Araza

This paper explores the inverse relationship between unemployment and inflation captured in the Phillips Curve, looking specifically at whether this macroeconomic concept holds outside of the United States in countries like Canada and Japan. After performing preliminary tests to check for the presence of both unit roots and structural breaks, taking first differences when appropriate, detrending the data, and ensuring stationarity, I employ a time series approach to scrutinize the relationship between unemployment and inflation. Specifically, I use a vector autoregressive model (VAR), impulse response functions (IRF), and different model adequacy tests, in addition to the notion of Granger causality, to show that the relationship emphasized in the Phillips Curve is not entirely present in Canada and Japan, although indicators of a smaller-scale relationship still hold. I theorize that it is instead largely dependent on the specific economic circumstances present within a country during periods of growth and contraction.

I. Introduction

Unemployment and inflation are two of the most important factors to consider when evaluating a country's economic situation. Although looking at these two variables separately can yield important insights, their relationship in particular has significant implications for monetary policy in any country. The most widely accepted link between unemployment and inflation principally emphasizes their inverse relationship, a macroeconomic finding conceptualized in the Phillips Curve. In *The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom,* Phillips (1958) describes the logic behind this relationship: when business activity rises, the increasing labor demand and following decreasing unemployment should lead to more rigorous bidding for labor services and therefore lead to an increasing rate in inflation, or as he calls it, *money wage rates*. This relationship is especially pertinent given the substantial changes that have occurred in the unemployment and inflation rates over the last several years following the COVID-19 pandemic. I seek to determine whether (a) this relationship holds over longer periods of time and (b) whether it is simply a product of unique economic circumstances in the United States or if it is generalizable to other countries. In particular, this paper seeks to answer these questions and explore if recent trends are suggestive of the need for new interpretations of the Phillips Curve by utilizing unemployment and inflation time series data from the years between 1960 and 2019 for Canada and Japan.

The remainder of the paper proceeds as follows. **Section 2** examines relevant literature papers relating to the economic theory and empirics behind the Phillips Curve and **Section 3** lays out extensive descriptions of the data in addition to summary statistics and general trends. In **Section 4**, I conduct various preliminary tests to ensure the proper use and interpretation of potentially non-stationary data with structural breaks. **Section 5** explores numerous econometric time series concepts and builds from my preliminary testing, and I also consider key questions about the Phillips Curve to potentially identify the aforementioned short or long-run relationship. Lastly, **Section 6** adds important context about the specific economic circumstances occurring in my countries of interest while describing conclusions. Additionally, I use this space to suggest future improvements that may be considered to improve the accuracy of my results.

II. Literature Review

Relevant research was apparent after the mid to late 1980's due to econometric tests being developed and the results for different papers are varying. Some papers conclude that the Phillips Curve is entirely irrelevant. Reichel (2004) builds upon Niskanen's (2002) original paper which declared no evidence of this inverse tradeoff where instead a positive relationship is indicated. While Niskanen's paper focuses on non-time series models, Reichel's paper utilizes the ADF, KPSS, and ERS tests which mainly lead to an integration of order one (I(1)) for unemployment and inflation, and the ECM test for cointegration where no country exhibits a long run relationship and very few exhibit a short run. In most cases, the curve does not pass basic differencing and cointegration tests as spurious regression occurs. Dua and Gaur (2010) adopted numerous unit root tests (ADF, PP, KPSS), an ARIMA model and tested for different structural breaks for developed and developing Asian countries using quarterly data from the 1990's to 2005. Testing the Phillips Curve indicated that every country had a unit root, no

structural breaks were detected using a Chow test, and ultimately the backwards Phillips Curve provides a worse fit compared to a forward-looking curve (a positive relationship).

Many papers conclude a nuanced opinion of the Phillips Curve for numerous countries and time periods. Patrick Nüβ (2013) explores this relationship in Germany from 1970 to 2012 with the ADF unit root test to ensure I(1) for all variables and the Engle-Granger cointegration test with significant results. No inverse relationship existed in the short run and once again, there was a potentially biased positive trend. However, significant evidence of a long-run Phillips Curve was found which lined up with numerous macroeconomic situations in Germany's history and the European Monetary Union's general macroeconomic policy. Mustafa and Rahman (2017) implement annual data in the United States from 1930 to 2016 for DF-GLS and Ng-Perron unit root tests along with ARDL Bounds cointegration testing. Unit root tests are stationary with I(1) behavior and cointegration was confirmed with similar ECM conclusions as Reichel's paper. They believed there is validity to a long run Phillips Curve where the Fed can use this relationship to lead the economy, however the short run results are generally weak and unable to provide much evidence for an inverse relationship. There exists research of both long and short run prominence of the Phillips Curve as well. Islam, Shahbaz, and Shabbir (2011) explore the curve in North Cyprus and implement ADF for a unit root and ARDL, DOLS (long run) and ECM (short run) for cointegration. As with the others, ADF was stationary with I(1) and every cointegration test was significant, meaning that the Phillips Curve exists in both the long and short run, which may provide some insight into the curve in smaller world economies. The goal is to determine which section this specific dataset falls within. Will the findings from this paper lead to the inapplicability of the typical Phillips Curve relationship or will it lead to more complicated outcomes?

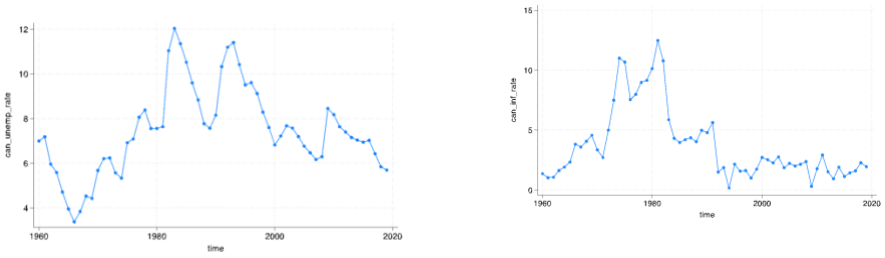
III. Data and Descriptive Statistics

In this analysis, I use annual data obtained from labor force surveys through the OECD to retrieve unemployment rates for Canada and Japan and the World Bank to acquire inflation rates from the IMF for these same countries. Unemployment and inflation rates for Canada and Japan lead to four response variables with time being the explanatory variable. The unemployment rate is the amount of unemployed people divided by the total labor force, which is the total number of those employed and unemployed. Unemployed people are represented as working aged people without work, who are available and taking steps to find work, making this definition more internationally applicable than the definition of unemployment in the United States. The inflation rate is measured by the CPI which represents the percent change in the price of an average consumer's basket of goods and services.

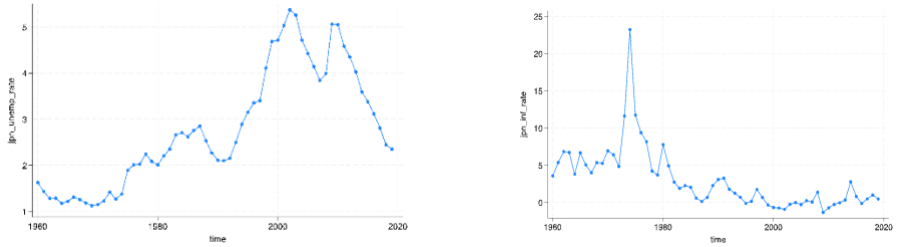
Large economic booms in both countries following World War 2 leading to economic prominence in the 1960's led to choosing the starting year of 1960, limiting economic recessions from significantly collapsing their economies. Poorer countries usually experience more frequent and impactful recessions than richer ones, leading to permanent potential output losses, as stated in an IMF article titled *The Economic Scars of Crises and Recessions* by Valerie Cerra and Sweta C. Saxena (2018). World Development Indicators as part of The World Bank indicate that Japan and Canada have the third and ninth highest nominal GDP with $4.231 trillion and $2.140 trillion respectively in 2022. However, both these countries experienced recessions: Canada with three

(two in the early 1980's and 1990's along with the global financial crisis of 2008) and Japan with one major long-term recession due to the collapse of the Japanese asset price bubble in 1992. Ending the data in 2019 continues the effort to prevent abnormal circumstances and potential correlated shocks from affecting the outcomes of this paper, such as the 2020 COVID-19 pandemic. Figures 1 through 4 reveal the unemployment and inflation graphs from 1960 to 2019 for Canada and Japan. These graphs have general trends (nonconstant means), and they will individually help determine if that inverse relationship exists when put together.

Figures 1 and 2- Canada's Unemployment Rate and Inflation Rate over Time



Figures 3 and 4: Japan's Unemployment Rate and Inflation Rate over Time



Note: All Graphs are read from Left to Right and Top to Bottom

Some interesting summary statistics include Canada's mean unemployment rate being three times as high as Japan's and the range of Japan's inflation rate being around twice as large as Canada's. In any time series model, validating stationary data is necessary before any type of model selection. Stationarity is present only when the variables' mean and variance are constant and when the covariance is independent of time, only its own lagged values. The data could also be trend stationary where the mean can change over time, but everything else is the same. Looking at each individual graph cannot prove stationary data by observing the nonconstant means and variances; testing is necessary.

IV. Preliminary Tests

To ensure the data is stationary, I computed unit root tests for all four variables to see what transformations are necessary. The first unit root test I wanted to use was the augmented Dickey-Fuller test (Levendis, 2018) which was initially used to determine if the data is stationary or trend stationary where the error term is not serially correlated. However, further continuation to improve these tests led to the creation of the DF-GLS test (Levendis, 2018) which can now distinguish the difference between alternatives who are near the test statistics or bigger than them

(near the unit-root process) and gain power when deterministic terms are added to the regressions.

Table 1 reveals the following for this test and none of the test statistics are greater than the five percent critical values except Japan's inflation rate for five percent in Ng-Perron, signifying many unit roots and non-stationarity. I also utilized the KPSS test (Levendis 2018) which holds a different intuition as it counteracts the lower power of the ADF test where the null hypothesis is a stationary variable, and the alternative hypothesis proves a unit root. The test for every variable is shown in Table 3 where this test shows significance for both Japan's unemployment and inflation rates as both test critical values cannot be rejected at the five percent level.[52] Before any next steps, this specific dataset requires further testing given the presence of structural breaks.

Table 1- DF-GLS Test for All Variables

	Lag Selection	Number of Lags	Test Statistic	Crit Value (5%)
can_unemp_rate	MIN SIC	1	-2.416	-3.171
can_inf_rate	MIN SIC	1	-2.899	-3.183
jpn_unemp_rate	Ng-Perron	3	-2.165	-3.090
jpn_inf_rate	Ng-Perron	0	-3.446**	-3.147

*Note (for all tables/regression results): *** p<0.01, ** p<0.05, * p<0.10*

Table 2- KPSS Test for All Variables

	Lag Order	Test Statistic	Crit Value (10%)	Crit Value (5%)
can_unemp_rate	5	0.215**	0.119	0.146
can_inf_rate	5	0.148**	0.119	0.146
jpn_unemp_rate	5	0.116	0.119	0.146
jpn_inf_rate	5	0.0968	0.119	0.146

These are unexpected changes in values over time that come with events like recessions that exist in the data. Perron stated that having a structural break in the series will bias the test statistics for towards nonrejection with the knowledge of the year of the break. Therefore, Yabu and Perron (2009) created a test that endogenously determines the break year dependent on the type of change in the trend (only the slope of the trend changes and not the intercept for all four variables). The break years for all four models are 1986 for Canada's unemployment, 1976 for their inflation, 2011 for Japan's unemployment, and 1974 for their inflation. After identifying the break, I conducted the Kim and Perron (2009) test that allows for a break under both null and alternative hypotheses, improving the test power while keeping the limit distribution on par compared to if a known break. I tested for break dates under this test to see the results (1982 for Canada's unemployment and inflation, 2009 for Japan's unemployment, and 1974 for inflation),

[52] I implemented ADF and PP unit root tests which had similar results to the DF-GLS test where Japan's inflation rate was statistically significant at the five percent level and therefore stationary.

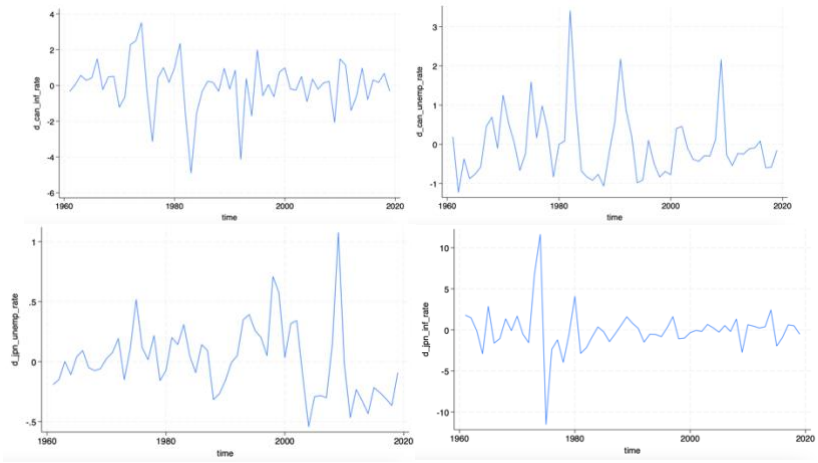
and they matched up better with the actual shocks of these countries, so I used these for the test.[53]

Table 3-Kim-Perron Test for All Variables

	Break Date	Lag Number	Test Statistic	Crit Value (5%)
can_unemp_rate	1982	1	-4.016	-4.05
can_inf_rate	1982	1	-2.8748	-4.05
jpn_unemp_rate	2009	3	-3.7407	-3.99
jpn_inf_rate	1974	0	-3.7976	-3.81

Table 3 reveals the numbers for each variable, and even when accounting for a structural break, these variables all have a unit root, even for Japan's inflation rate. It seems the structural break did assist in preventing the natural bias towards nonrejection as before the test statistics were quite different from the critical values, but these ones are extremely close; however, Japan's inflation changed from not having a unit root to having one. The DF-GLS produces interesting outcomes as Japan's unemployment rate remains non-stationary as its test statistic is less than the critical value at five percent and the KPSS produces all stationary variables. Since twice differencing a variable is not commonly used in similar economic papers, I kept Japan's unemployment differenced once.

Figures 5-8- Differenced Graphs of All Variables (Canada's Unemployment, Canada's Inflation, Japan's Unemployment, Japan's Inflation) over Time



[53] I utilized the AIC model selection for the number of lags and specific asymptotic critical values for a slope change.

Table 4- DF-GLS for All Differenced Variables

	Lag Selection	Number of Lags	Test Statistic	Crit Value (1%)
d_can_unemp_rate	MIN MAIC	1	-5.225***	-3.736
d_can_inf_rate	Ng-Perron	0	-6.814***	-3.736
d_jpn_unemp_rate	MIN SIC	2	-2.522	-3.736
d_jpn_inf_rate	MIN SIC	1	-6.841***	-3.736

These overall findings require better estimation with further steps and tests. Reasons for these statistics include either a trend-stationary or difference-stationary component in the model and taking the first difference of every variable allows us to know if stationarity is achievable. Figures 5 through 8 present the differenced graphs for each variable, whereby the various general increases and decreases in the initial graphs over time are mostly diminished or removed. For the differenced data, I ran the same unit root tests I did with the data before differencing.

Table 5-KPSS Test for All Differenced Variables

	Lag Order	Test Statistic	Critical Value (10%)
d_can_unemp_rate	4	0.108	0.347
d_can_inf_rate	27	0.239	0.347
d_jpn_unemp_rate	4	0.196	0.347
d_jpn_inf_rate	6	0.0828	0.347

V.Further Testing and Model Selection

With stationary variables, I constructed a VAR model which was designed by Christopher Sims (1980) in order to display the relationships between different variables. For this paper, the interdependencies I want to measure are Canada's unemployment and inflation rates along with Japan's unemployment and inflation rates.[54]

Table 6 reveals the results of testing the VAR model. The bolded variables serve as the regressands with the lagged and differenced variables underneath them being the regressors in each pairing of understanding variable relationships. It is clear that both models are not statistically significant even with choosing the optimal lag amounts as not all of the coefficients are significant.[55] However, Canada's model is still better than Japan's, with three out of the four being significant and all the inflation-unemployment/unemployment-inflation pairings being significant compared to Japan's two out of four.

[54] Optimal lag amounts of 1(Canada)and 2 (Japan) were chosen based on AIC, BIC, and HQIC lag selection models.

[55] None of the constants were significant as well.

Table 6-VAR Model Results for Both Countries

	Canada Coef.	Standard Error	Japan Coef.	Standard Error
d_can_inf_rate				
L.d_can_inf_rate	-.069	0.121		
L.d_can_unemp_rate	-.837***	0.200		
d_jpn_inf_rate				
L.d_jpn_inf_rate			-.183	0.135
L.d_jpn_unemp_rate			-1.941	1.265
d_can_unemp_rate				
L.d_can_inf_rate	.194**	0.076		
L.d_can_unemp_rate	.438***	0.124		
d_jpn_unemp_rate				
L.d_jpn_inf_rate			.032**	0.013
L.d_jpn_unemp_rate			.563***	0.117

The Phillips Curve implies an inverse relationship between unemployment and inflation, and even when looking at the statistically significant coefficients between pairings of unemployment and inflation, they are a mix of positive and negative results dependent on different variables when they should all be negative.

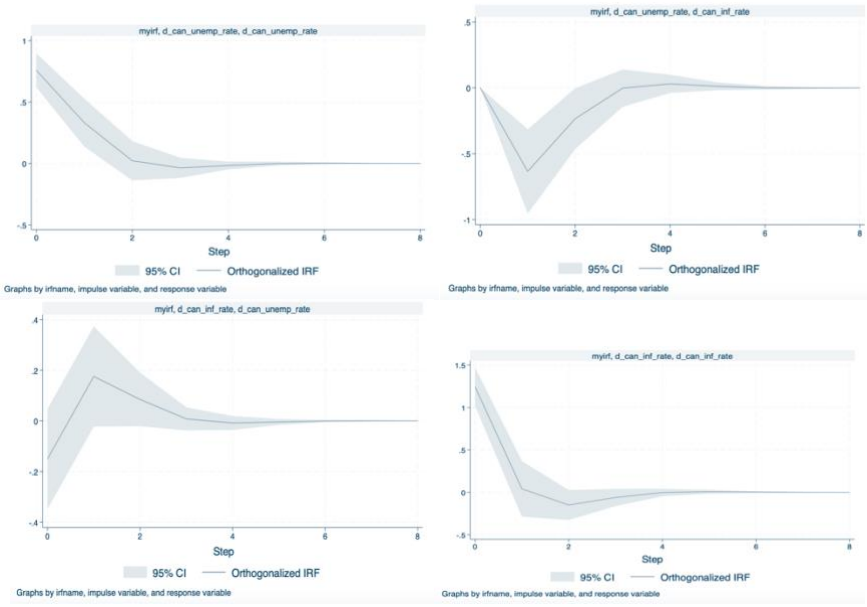
Table 7-Granger Causality Test for Canada and Japan

	Equation	Excluded	chi2	df	p > chi2
Canada	d_can_inf_rate	d_can_unemp_rate	17.499***	1	0.000
	d_can_inf_rate	ALL	17.499***	1	0.000
	d_can_unemp_rate	d_can_inf_rate	6.608**	1	0.010
	d_can_unemp_rate	ALL	6.608**	1	0.010
Japan	d_jpn_inf_rate	d_jpn_unemp_rate	2.355	1	0.125
	d_jpn_inf_rate	ALL	2.355	1	0.125
	d_jpn_unemp_rate	d_jpn_inf_rate	6.422***	1	0.011
	d_jpn_unemp_rate	ALL	6.422***	1	0.011

Another test that could yield important results about the Phillips Curve relationship is the test for Granger causality, which essentially measures if implementing previous values of a

variable helps in predicting a value of a different variable (Levendis 2018).[56] In this case, unemployment would "Granger cause" inflation if previous values of unemployment would improve predictions of inflation and vice versa. Table 7 reveals the results which show that for Canada, unemployment Granger causes inflation and vice versa, but for Japan, only unemployment Granger causes inflation. While this can provide insight on causality, it does not describe the detailed shocks that variables can have on themselves or the others, so to determine these short and long run impacts, I employed impulse response functions (IRF's).

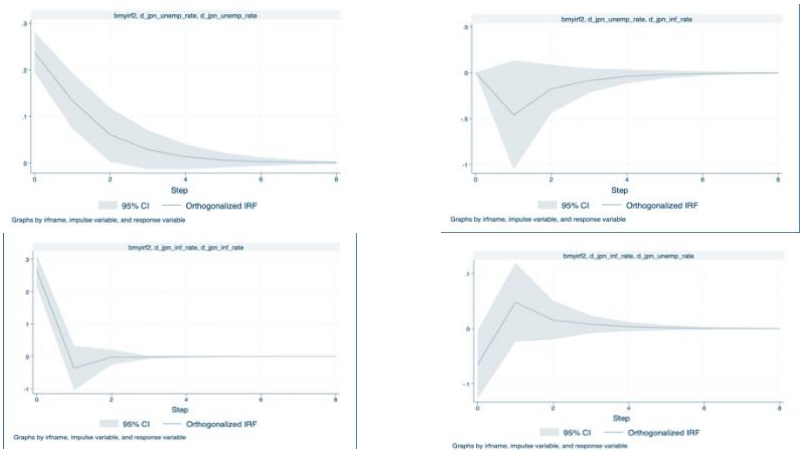
***Figures 9-12: OIRF Graphs for Canada (Unemployment-Unemployment, Unemployment-Inflation, Inflation-Unemployment, Inflation-Inflation*)**



Specifically, I used orthogonalized impulse response functions (OIRF's) as they address potential correlation of shocks across variables and can measure impacts of exogenous changes in a variable like unemployment and singularly track those effects on a variable like inflation. Figures 9 through 12 reveal the OIRFs for Canada's variables and Figures 13 through 16 inform the same for Japan. For Canada, both variables' shocks on itself initially are higher than their baseline, but after two years it returns to zero. For the effects of an unemployment rate shock on inflation, the initial reaction is a sudden decrease of inflation in a year, but it corrects itself in two years and returns to zero in the third year. The inflation rate shock on unemployment is reverse (sudden decrease in a year, takes two years to correct itself in the long-run). Japan's results are similar to self-imposed shocks that have an initial positive bump, but eventually go to zero (inflation after two years, unemployment gradually after six).

[56] Before this, I performed a Lagrange Multiplier test that showed no autocorrelation for the residuals in Canada's Var but showed for Japan's residuals. I additionally tested for stability where the moduli of eigenvalues in each VAR resided inside the unit circle, ensuring a stationary model.

Figures 13-16: OIRF Graphs for Japan (Unemployment-Unemployment, Unemployment-Inflation, Inflation-Unemployment, Inflation-Inflation)



The shocks of one variable on the other are also similar, as they generally hover a little above or below zero before stabilizing at zero in the seventh year. The important takeaways from every OIRF graph are that there is some evidence of a short run relationship as shocks to unemployment lead to an initial inverse reaction for inflation for both Canada and Japan. However, in the long-run, every graph points to an insignificant relationship between these two variables.

Adjacent to the OIRF's, I also calculated the Forecast Error Variance Decompositions' (FEVD's) for the variables, which reveals how much of the variance in, let's say inflation, is due to a shock in unemployment. I did not include the graphs as the results did not give any significant further insight. For Canada's variables' shocks on themselves, the graph maintained a high level, meaning that a lot of the variance was due to its own shock (0.8 and above on a 0 to 1 scale) while for any variables' shock on the other variable, the graph maintained a low level, meaning that not much variance was due to the shock in the other variable (0.2 and below). For Japan's, shocks on themselves were above 0.9 and shocks on the other variable was lower than 0.1. All of these results surrounding the VAR model are held in question because the initial model was not entirely statistically significant. Because Canada's variables had most lags as significant, those results could be taken with more importance than Japan.[57]

VI. Conclusion

I set out to discover the validity of the Phillips Curve and if the macroeconomic theory behind this concept was still relevant in modern economies. And after accounting for numerous factors, the Phillips Curve is not conclusively present, even if there are some smaller signs of that inverse relationship and the relationship is extremely nuanced. The results of both of Canada's variables "Granger causing" each other and Japan's unemployment Granger causing inflation is a sign of correlation even if further causality is unattainable and the OIRF graphs reveal initial

[57] I additionally tested for cointegration to check for a long-run relationship, but the results were inconsistent.

short run inverse relationships following a shock. In the short term, whether the shock occurs with unemployment and inflation, there seems to be an impact even if they represent a low percentage of that shock. Every other result led to inconclusive evidence, as the VAR model itself had statistically insignificant values with no residual autocorrelation and the FEVD's were unsurprising. There are more signs of Canada's being stronger than Japan's resulting from coinciding break dates determined by the Kim-Perron test, almost fully significant coefficients in the VAR model, and variables that Granger cause each other. However, there is some historical context that may help interpret these results and help understand future extensions around this.

Unlike Canada's variables, the specific break dates for Japanese unemployment and inflation were different (1974 and 2009) and did not represent the largest economic shock in Japan that stagnated economic growth for the following thirty years and reshaped monetary policy. The economic state of Japan during the 1990's and on is called the Lost Decades which was a result of an asset pricing bubble collapse in their real estate market in the early 1990's. Economic policies before and after the shock explain why the relationship is not as strong as Canada's, as when the economy was soaring in the 1980's, Japan's central bank was afraid of rising asset prices and higher inflation, leading to the bank shutting down the money supply. The bank raised interest rates even when equity values fell as they were scared of higher appreciating housing values, so when the economy dramatically crashed and the bank tried to lower interest rates, the price was already paid. This led to significant deflation where no matter any deficit spending or stimulus packages, inflation will never be as high as it was before the crash due to this disincentivized investment and negative future outlook. Ultimately, Japan's history leads to constant low inflation, no matter any large recession or economic rebound. In any situation where unemployment rises significantly, such as the pandemic, and the government needs to stimulate the economy, no significant monetary policy in Japan will lead to a large rise in inflation.

Often, the necessary economic conditions and history that can result in a situation where the Phillips Curve can be relevant or limited. Intricacies surrounding larger countries may result in too many factors fundamentally changing the results of testing and modeling done in this paper. This macroeconomic analysis may be better suited in the future for any country without any major recession, no matter the wealth of the country. Countries react to economic activity differently and that economic mindset can alter a theory-based relationship. Much economic theory has dived into the quadratic nature of the Phillips Curve and whether it has flattened out or not, and this might be a situation where countries have one or the other. Numerous time series techniques and methods are relatively modern and in their infant stages where future testing methods will exist in future extensions that will account for more deviations that may occur in different countries. Ultimately, a decade or two of economic tracking could determine the future of the Phillips Curve.

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