REAL WAGE, INFLATION AND LABOR PRODUCTIVITY IN CANADA

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Abstract

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This dissertation seeks to apply the framework of Kumar, Webber, and Perry (2012), who studied the interconnection between the inflation rate, real wages, and labor productivity in Australia to the Canadian context. To attain the primary objective of this research, the study utilized monthly data from January 2000 to 2023, sourced from CANSIM, Statistics Canada. The unit root test showed that all variables were stationary at the first level differential, paving the way for applying the Vector Error Correction Model and Granger causality, which estimate the long and short-run effects. The main finding shows that the inflation rate and real wages positively drive labor productivity; thus, a 1% surge in real wage propels labor productivity to increase by 0.406%, while a 1% rise in inflation rate increases labor productivity by 0.115% in the long run, holding all other factors constant. In the short run, my results indicate a two-way directional Granger causality between the inflation rate and real wage, suggesting that past values of inflation influence current real wages and, reciprocally, past values of real wages impact current inflation. Although this study partially agrees with Kumar et al.'s (2012) findings, the partial differences in both studies could be attributed to the heterogeneous nature of individual economies.

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1 Introduction

The interconnection between inflation rate, real wages, and labor productivity is pivotal in understanding various global economic dynamics, including developed and emerging economies. The interaction among important macroeconomic variables, real wages, inflation rate, and productivity, can be theorized for several reasons, as Bårdsen, Hurn, and McHugh (2007) suggested. Real wages, defined as the purchasing power of household income after accounting for inflation, remain one of the important indicators in measuring the well-being of labor and its willingness to enact productivity. On the other hand, inflation erodes the household's purchasing power and influences firms' future decisions regarding investment, production techniques, and capital depreciation. The relationship between these variables shapes labor markets and policy-making decisions and ultimately affects overall economic growth.

In recent years, emerging economic disruptions, including the global pandemic, geopolitical tensions, and supply chain constraints, resulted in additional stress on various economies, exacerbating wage stagnation and upsurging the risk of inflation. Specifcally, the persistent unrest in the Middle East, periodic market crashes, the ongoing conflict between Russia and Ukraine, and the lingering effects of the COVID-19 pandemic continue to drive inflation, disrupting production across most economies and destabilizing real wages. Following these interruptions, assessing the influence of real wages and inflation rate on labor productivity resurges the interest of many researchers. Canada's inflation peaked at 8.1% in June 2022, underlining the persistent pressure challenging the economy in recent times. Theoretical frameworks suggest that higher real wages will enhance labor productivity by improving worker satisfaction, reducing turnover, and promoting higher levels of effort. However, excessive wage growth in the absence of corresponding productivity gains can fuel inflationary pressures, which, in turn, undermine the very real wage improvements that initially boosted productivity. Conversely, inflation without commensurate wage increases diminishes real wages, potentially demotivating workers and leading to a productivity decline. Two major schools of thought regarding the relationship between productivity and real wages exist. The first posits that the opportunity cost of job loss rises with an increase in real wages. This motivates labor to put in more effort to avoid unemployment, aligning with Keynes (1924) efficient wage hypothesis. Many economists, including Wakeford (2004), suggest a positive connection between productivity and real wages. The second argues that an increase in real wage raises production costs, inducing firms to substitute labor with capital and increasing labor's marginal productivity. Gordon (1987) adds that this labor-capital substitution can result in an unsustainable rise in real wages. Hendry (2001) posits that an increase in demand for production inputs, including labor, leads to production costs, posing an upside pressure on inflation. This underlines the relationship between inflation and real wages.

This paper seeks to apply the methodology developed by Kumar, Webber, and Perry (2012), originally used to assess real wages, inflation and labor productivity in Australia, to the Canadian context. By adopting their econometric approach, I will examine how the fluctuations in inflation and real wages have influenced labor productivity in Canada. This comparative analysis is important because it will aid us in assessing whether the findings from Australia truly hold in Canada amidst the different inflation, wage, and labor dynamics in both countries.

The decision to apply Kumar et al.'s methodology to Canada is motivated by the recent skyrocketing inflation, potentially causing real wage stagnation globally. In this paper, I seek to review the interrelational effect of inflation and real wages on productivity. Given the importance of these major economic indicators for policymakers, households, and businesses, a detailed analysis tailored to the Canadian economy can offer valuable insight. The main objective of this study is to provide a clear understanding of how inflation and real wages interact to impact productivity for the Canadian economy over the period of 2000 to 2023. The findings will contribute to policy formulation, aiding decision-makers with information regarding wage growth, taming inflation, and productivity enhancement in Canada.

The structure of the paper is as follows: Section 2 provides a brief review of the relevant literature on real wages, inflation, and productivity. Section 3 introduces the theoretical model. Section 4 details the research methodology and data, while Section 5 presents the empirical results and contrasts them with the findings of Kumar et al. (2012). Section 6 concludes with a summary of the paper's key insights.

2 Literature Review

Empirical research on the relationship between real wages, inflation, and productivity has been extensively studied for centuries. Scholars have conducted numerous investigations into this area, offering various perspectives and insights over time. The variations across different studies arise from differences in data samples, time ranges, selected variables, and econometric estimations. Several studies have found evidence of a long-term connection between inflation, real wages, and labor productivity. Many studies indicate that a country's real wage is often considered a significant factor in driving labor productivity, while inflation inversely drives productivity. However, a few studies have found the contrary to labor productivity from both real wage and inflation. The following literature review summarizes the important conclusions drawn, the differing perspectives in the debate, and the methodologies developed to analyze real wages, inflation, and labor productivity.

In Öztürk et al. (2019) panel data, the authors applied the Johansen cointegration test and vector error correction model to examine the role of productivity in determining labor wages within New Zealand's construction industry. Their findings indicate that, in the long run, the labor productivity index positively impacts wages. As a result, an increase in real wages corresponds to a proportional rise in labor productivity. Basri et al. (2018) demonstrate that real wages positively influence short- and long-term labor productivity. Utilizing a dynamic heterogeneous panel model, they employ Pooled Mean Group and Mean Group estimators to analyze the impact of real wages and industry-specific factors on the labor productivity of 44 sub-manufacturing industries in Malaysia. İkizler and Çelik (2022) explore the causal relationship between real wages and productivity in the Turkish economy using Granger causality analysis to determine the direction of causation. The findings reveal that labor productivity significantly influences real wage fluctuations. Furthermore, the study identifies a two-way directional causality between labor productivity and the real unit wage index in the quarrying and mining sector. Tung (2020) analyzes the factors influencing labor productivity in an emerging Asian market using data from Vietnam's retail industry. The research utilized quarterly data from 69 convenience stores, covering the period from 2014 to 2015. Empirical findings revealed that real wages were statistically significant and positively affected labor productivity. Among the limited number of studies, Pham (2015) identified a negative relationship between real wages and labor productivity. Using fixed effects models, the study examined the influence of minimum wage on U.S. labor productivity with state-level data from 1997 to 2013. The findings showed no evidence that raising the minimum wage positively influences labor productivity. Additionally, the study revealed that states with higher labor productivity were more probable to have higher minimum wages, with both minimum wage and labor productivity increasing over time. Similarly, Mora, Lòpez-Tamayo, and Suriñach (2005) analyze wages and productivity across 11 Euro-area countries from 1981 to 2001, using panel cointegration estimates. The results indicate a decline in the variation of wages and unit labor costs but not productivity. A notable distinction was observed between real and nominal wages: nominal wages showed signs of convergence in countries with higher inflation and faster-growing unit labor costs.

Liyanage (2021) investigates the influence of inflation on labor productivity in Sri Lanka from 2006 to 2020 using a univariate Vector Auto Regression model. The findings reveal a negative short-run relationship between inflation and labor productivity. However, the analysis found no evidence of Granger causality between the two variables. Piper, Ferrari-Filho, and Lélis (2020) applied a structural vector autoregressive model to Brazilian productivity and inflation data, revealing a negative relationship between the country's manufacturing industry and inflation. The results also showed an inelastic relationship, meaning that productivity increases have a smaller-than-expected impact on controlling inflation. Bans-Akutey, Yaw Deh, and Mohammed (2016) examine the impact of inflation on productivity in Ghana's manufacturing sector, utilizing annual time series data from 1968 to 2013. Applying the Johansen test (JT), Vector Error Correction Model (VECM), and Ordinary Least Squares (OLS), the study identifies a significant long-run relationship between inflation and manufacturing sector productivity. While the VECM results suggest an insignificant short-run relationship, the OLS analysis reveals a significant negative association, indicating that inflation has contributed to a decline in productivity within the manufacturing sector. Lewis, Villa, and Wolters (2018) compare labor productivity and inflation dynamics in the Euro Area and the U.S. Using Bayesian estimation, they found that the returns to hours in production exceed unity and are significantly higher in the Euro Area compared to the U.S. This explains the differing labor productivity cyclicality between the two regions. Additionally, the authors also find that the effort margin influences inflation dynamics, as the procyclicality of labor productivity reduces real marginal costs. On the contrary, Mehra (1991) analyzes U.S. data to investigate the relationship between inflation and wages adjusted for productivity. While many studies have reported an inverse relationship between inflation and labor productivity, their findings reveal a positive long-run effect of inflation on labor productivity.

Although there is limited literature on the influence of inflation, real wages, and labor productivity, a few studies have made notable contributions to this topic. Tang (2014) applied the bound testing approach to cointegration and the Granger causality test to examine the relationship between labor productivity, inflation, and real wages in Malaysia. Albeit numerous empirical studies have identified a positive linear relationship between real wages and labor productivity, Tang's results reveal a non-monotonic, quadratic relationship in both the short run and long run. The study also found that inflation negatively impacts labor productivity in both the short and long run. Thus, inflation and real wages are crucial in determining labor productivity in Malaysia. Dritsaki (2016) empirically supports the notion that real wages positively affect labor productivity while inflation exerts a negative impact. Their study investigates the effects of inflation and real wages on labor productivity in Bulgaria and Romania, using the Autoregressive Distributed Lag (ARDL) model and causality tests. The results show that real wages significantly influence labor productivity more than inflation. Additionally, the study reveals a one-way relationship from inflation to real wages in Bulgaria and from real wages to labor productivity in Romania. Eryılmaz and Bakir (2018) found empirical evidence of a long-term relationship between labor productivity, inflation, and real wages using the Vector Error Correction Model. In the long run, this relationship is driven by productivity and inflation, which influence real wages. Additionally, the study identified a short-term causal relationship. Their study also revealed a short-term causal relationship from inflation to real wages and productivity. Slaveski and Kozheski (2024) investigate the interrelations among wages, inflation, and labor productivity in Central & Southeast European countries. The study identifies short-term causality among wages, inflation, and labor productivity, including a bidirectional causal relationship between wages and inflation with labor productivity. The findings also reveal that wage shocks significantly influence long-term labor productivity and inflation. Kumar, Webber, and Perry (2012) conducted an empirical analysis of the effects of real wages and inflation on productivity in Australia, utilizing annual data from 1965 to 2007. The study detected a structural break in 1985 and established a significant cointegration relationship between real wages, inflation, and productivity. Across various econometric models, the results consistently showed that real wages positively impact labor productivity, whereas inflation negatively affects it. Furthermore, the Granger causality tests demonstrated a two-way relationship between real wages and productivity. Over the long term, inflation and real wages were shown to be Granger-cause productivity.

The relationship between inflation, real wages, and labor productivity continues to be of great importance due to its profound impact on both emerging and developed economies. Research on this topic offers valuable insights into the short- and long-term economic effects, providing policymakers with crucial information for decision-making. However, the dynamics of inflation, real wages, and productivity are constantly evolving, and their underlying effects remain only partially understood, with varying perspectives from scholars. Building on recent data, this paper adopts the framework of Kumar, Webber, and Perry (2012) to investigate the effects of real wages, inflation, and labor productivity in Canada from 2000 to 2023.

3 Methodology

3.1 Research Design

This study adopts a quantitative approach, focusing on collecting and analyzing numerical data to facilitate estimation. A causal research design was chosen to align with the research objectives, as it seeks to explore the cause-and-effect relationships between inflation, real wages and labor productivity. It is essential to identify and track changes in the influencing variables to determine causality and assess how these variations affect the dependent variables. The design is well-suited to the study, as it clearly demonstrates the effects of inflation and real wages on labor productivity.

3.2 Data

As noted by Kumar, Webber, and Perry (2012), real wages and inflation were chosen as key determinants of labor productivity. Their paper uses data on Australia for the period 1965 to 2007. I gathered monthly secondary data from Statistics Canada's CANSIM for this study. Consumer Price Index (CANSIM 326-0023 / Table 18-10-0256-01), Employment by Industry (CANSIM 282-0088 / Table 14-10-0355), Employee wage by Industry (CANSIM 282-0071 / Table 14-10-0063-01), and Gross Domestic Product at basic price by Industry (CANSIM 379-8031 / Table 36-10-0491) were sourced from Statistics Canada's CANSIM database.[1]

The inflation rate is represented by the growth rate of the consumer price index. The manufacturing sector's hourly wage is a proxy for real wages, while labor productivity is captured by manufacturing output per labor. Real wages are determined by dividing the manufacturing sector's nominal hourly wage by the consumer price index.[2] Productivity is calculated by dividing the manufacturing sector's gross domestic product (in monetary terms) by the industry's total employment number. All variables are transformed into logarithmic form to mitigate heteroscedasticity and ensure the validity of econometric testing procedures. Table 1 presents a descriptive analysis of the variables used in the study. [3]The secondary data spans the period from 2000 to 2023, with monthly observations, resulting in a total of 288 data points for each variable.

This study utilizes Stata, Excel, and Eviews software for the analysis. These tools enable the performance of critical analyses, ensuring precision and reliability in examining time series data.

3.3 Model Specification

The research aims at empirically assess the impact of inflation and real wages on productivity within the Canadian economy. To facilitate this analysis, the natural logarithm was applied to both real wages and productivity, making the variables unit-free and enabling the interpretation of their coefficients as elasticities Hondroyiannis and Papapetrou (1997); Strauss and Wohar (2004). The study employs a time series regression model consistent with the production function equation specification used by Kumar, Webber, and Perry (2012).

1. Due to limitations in data availability, the study utilized seasonally unadjusted wage data instead of seasonally adjusted data.

2. Real wage was calculated by dividing the wage by the Consumer Price Index, and productivity was determined by dividing the total output of the industry by its total employment.

3. Monthly data were used to increase the sample size of the time series analysis and yield more reliable results.

$$\ln Y_t = \alpha + \beta_1 \ln W_t + \beta_2 \pi_t + \epsilon_t. \tag{1}$$

The variables in the study are denoted as follows: $\ln Y$ for the natural log of productivity, $\ln W$ for the natural log of real wages, π for the inflation rate, and ϵ representing the residual term, which is independent and identically distributed. β_1 and β_2 are the respective elasticity' of wages and inflation on productivity. The variable t (where $t = 1, 2, 3, 4, \ldots$) represents the time-varying aspect of these variables.

The expected signs of coefficient β_1 and β_2 are positive and negative, respectively. This is because higher real wages often incentivize workers to be more productive, as they are compensated better for their efforts, while higher inflation may increase the cost of living, reduce purchasing power, and create uncertainty, potentially leading to reduced productivity. However, inflation could have a positive effect if moderate inflation stimulates investment in capital and technology, which could enhance productivity.

3.4 Analytical Procedure

Given the non-stationary nature of macroeconomic time series, it is well established in the literature that spurious correlations can occur among non-stationary variables over time (Phillips 1986; Granger and Newbold 1974). Therefore, the study first examined the order of integration of the variables to evaluate their stationarity. To test for unit roots in time series, I employed standard unit root tests described by Dickey and Fuller (1979, 1981) and Phillips and Perron (1988). According to Im, Pesaran, and Shin (2003), the time series unit root test for both standard tests follows the equation below:

$$\Delta y_{it} = \kappa_i + \phi y_{it-1} + \varepsilon_{it} + \sum_{j=1}^{k} \delta_{ij} \Delta y_{it-j} + \nu_{it},$$

where Δy_{it} is the dependent variable in first differences, ϕy_{it-1} is the lagged dependent variable, κ_i as the constant term, $\sum_{j=1}^{k} \delta_{ij}$ is the summation over lags of differenced variables and ϕy_{it-1} and ν_{it} are the error terms.

The hypothesis of the tests is defined as follows:

$$H_0 : \text{The variable has a unit root (non-stationary)},$$
$$H_1 : \text{The variable is stationary (no unit root)}.$$

The ADF test statistics for each variable calculated follow a standardized t-bar statistics distribution is estimated using the equation below:

$$t = \frac{\hat{\gamma}}{\text{SE}(\hat{\gamma})},$$

where $\hat{\gamma}$ is the estimated coefficient of $y_{t-1},$ while $\text{SE}(\hat{\gamma})$ is the standard error of the estimate.

The initial stage involves testing the variables' unit root. I subsequently used the tests proposed by Gregory and Hansen (1996) to identify break dates within the cointegrating vector. The null hypothesis asserts no cointegration in the presence of structural breaks, while the alternative hypothesis indicates cointegration with structural breaks. These tests account for the endogeneity of the break date. The Gregory Hansen test follows a standardized t-bar statistics distribution. As proposed by Gregory and Hansen (1996), the test relies on several assumptions regarding structural breaks, such as i) a level shift, ii) a level shift with a trend, iii) a regime shift affecting both the intercept and slope coefficients, and iv) a regime shift involving changes to the intercept, trend, and slope coefficients. The test is designed to detect possible breakpoints within the cointegrating vector, with the null hypothesis formulated as follows:

$$H_0 : \text{No cointegration (no long-run relationship)},$$
$$H_1 : \text{Cointegration with a single structural break at an unknown time.}$$

If the variables exhibit stationarity at their levels, the Ordinary Least Squares (OLS) estimator can be utilized to explore the long-run relationship between real wages, inflation, and labor productivity. However, if all variables are stationary at their first differences and at least one cointegrating relationship exists, the Vector Error Correction Model (VECM) becomes the appropriate method for estimating the regression. According to Johansen and Juselius (1990), the Vector Autoregressive model (VAR) used to identify the presence of cointegrating vectors is defined below:

$$\Delta y_t = \alpha + \sum_{i=1}^{I} \Phi_i \Delta y_{t-i} + \beta y_{t-1} + \epsilon_{1t}.$$

Let y_t be a vector of $I(1)$ variables, which are nonstationary in their levels, and α represents a constant term.

Before proceeding, checking for cointegration between at least two variables is essential. I examined the lag order selection criteria to determine the optimal number of lags to include in the model. The lag specification model that yields the lowest values for either the Schwarz Bayesian Criterion (SBC) or the Akaike Information Criterion (AIC) is typically preferred. Johansen and Juselius (1990) maximum eigenvalue and trace test statistics are used to predict the number of cointegrating vectors in the model. Both tests allow for unrestricted or restricted intercepts, as well as restricted or no trends within the VAR model. Once the cointegrating vectors are identified, the next step is to estimate the cointegrating relationship. The Vector Error Correction Model and the Johansen Cointegration test follow a chi-squared distribution.

Before estimating the short-run equations, tests are performed to check for endogeneity and to confirm if the system of equations is identified. The exogeneity test is then performed if one independent variable does not cause changes in another variable (dependent) over time, using the Granger non-causality test. To establish Identification, I regressed the first differences of each variable on lagged residuals variables. When the error correction terms are significant and negative, it implies the model is well-specified, considered identified, and valid.

3.5 Granger Causality

Granger causality is conducted to determine whether one of the time series variables can be used to forecast another in the short and long run. The basis for conducting this test is the presence of cointegration among the variables in the estimation, indicating that the series are non-stationary but maintain a long-run equilibrium relationship. The VAR estimation at the first difference may yield biased results if the series are integrated into order one. Below are the equations used to estimate Engle and Granger (1987).

$$\Delta \ln Y_t = \Upsilon + \sum_{i=1}^{n} \theta_i \Delta \ln Y_{t-1} + \sum_{i=1}^{n} k_i \Delta \ln W_{t-1} + \sum_{i=1}^{n} m_i \Delta \ln \pi_{t-1} + \varphi_1 ECT_{t-1} + \varepsilon_{1t}, \quad (2)$$

$$\Delta \ln W_t = \Upsilon + \sum_{i=1}^{n} k_i \Delta \ln W_{t-1} + \sum_{i=1}^{n} \delta_i \Delta \ln Y_{t-1} + \sum_{i=1}^{n} \mu_i \Delta \ln \pi_{t-1} + \varphi_2 ECT_{t-1} + \varepsilon_{2t}, \quad (3)$$

$$\Delta \ln \pi_t = \Upsilon + \sum_{i=1}^{n} m_i \Delta \ln \pi_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta \ln W_{t-1} + \sum_{i=1}^{n} \omega_i \Delta \ln Y_{t-1} + \varphi_3 ECT_{t-1} + \varepsilon_{3t}. \quad (4)$$

The terms ϵ_{1t}, ϵ_{2t}, and ϵ_{3t} represent the independent errors. These errors have a mean of zero and finite covariance. ECT_{t-1} denotes the long-run cointegrating vector error.

3.6 Methodology Justification

The primary reason for selecting the Vector Error Correction Model (VECM) is on two key factors: its ability to handle data that are stationary at first differences and exhibit cointegration and its effectiveness in capturing the dynamic interactions between variables over different time horizons. The VECM is particularly well-suited for analyzing short and long-run dynamics, making it ideal for non-stationary time series data. Additionally, tests for autocorrelation and the Eigenvalue stability condition were performed to verify the stability and appropriateness of the model.

4 Empirical Results

This chapter presents my empirical results on how inflation and real wages have contributed to labor productivity in Canada from 2000 to 2023. Prior to conducting my econometric analysis, I examine the descriptive properties of the data to enlighten us on how the variables are expected to behave. Summary statistics and graphical analysis were conducted to provide insights into potential correlations and trends over time. Figure 1 presents a time series movement of all the variables used in this research. Table 2 also presents a descriptive analysis of the nature of the variables.

4.1 Unit Root Tests

It is presumed that non-stationary variables and error terms could lead to inconsistent and based estimates when Ordinary Least Squares are applied. Hence, Im, Pesaran, and Shin (2003) unit root test is used to analyze the stationarity of the variables. Tables 3 and 4 presented in the appendix show the results of Augmented Dickey-Fuller (ADF) and Phillips-Perron Unit Root Tests for three variables: thus Productivity, Real Wage, and Inflation. The tests are used to determine whether a time series is stationary and does not have a unit root or non-stationary and has a unit root.

4.1.1 Augmented Dickey-Fuller Unit Root Test

The ADF test results indicate that Productivity, Real Wage, and Inflation are all non-stationary in their levels but become stationary after first differencing, categorizing them as I(1) processes. For Productivity, the test statistic at levels (-3.333) yields a p-value of 0.061, which does not meet the 5% significance threshold, suggesting non-stationarity. However, after first differencing, the test statistic (-17.661, $p < 0.01$) is highly significant, indicating stationarity. Real Wage shows a similar pattern, with a level test statistic of -2.221 and a p-value of 0.478, confirming non-stationarity. When differenced, the test statistic becomes highly significant (-20.325, $p < 0.01$), indicating that while real wages exhibit cumulative changes over time, their growth rate remains stable. Lastly, Inflation is also non-stationary in levels, with a test statistic of -1.570 and a high p-value of 0.804. However, differencing yields a significant test statistic (-16.420, $p < 0.01$), indicating stationarity in the inflation rate.

4.1.2 Phillips-Perron Unit Root Test

The Phillips-Perron test produced a similar result to that of the Augmented Dickey-Fuller test. For Productivity, the level test statistic (-3.176) has a p-value of 0.0894, above the 5% threshold, indicating non-stationarity in its original form. However, after first differencing, the test statistic becomes highly significant (-17.906, $p < 0.01$), allowing the rejection of the null hypothesis. With Real Wage, the level test statistic is -2.259 with a p-value of 0.4569, also suggesting non-stationarity. Upon differencing, however, the test statistic becomes highly significant (-20.003, $p < 0.01$), indicating stationarity in the Real Wages. Inflation reported a level test statistic of -1.975 and p-value of 0.6152 reflecting a strong non-stationarity. After first differencing, the test statistic becomes significant (-16.757, $p < 0.01$). In conclusion, the Phillips-Perron test results indicate that Productivity, Real Wage, and Inflation are all non-stationary in levels but become stationary after first differencing.

4.2 Gregory-Hansen Cointegration Test

The Gregory-Hansen test, designed to detect potential structural breaks between non-stationary time series variables in the long-run relationship, is carried out. Due to market conditions, external and internal economic shocks, and policy changes, the Gregory-Hansen test identified a potential structural break in May 2020, coinciding with the declaration of COVID-19 as a global pandemic (level shift with trend). Despite identifying a potential structural break, the test found no evidence of cointegration between inflation, real wages, and productivity. The decision rule states that the null hypothesis should be rejected if the absolute test statistics exceed the 5% critical value. Since the absolute test statistics are lower than the critical values, I failed to reject the null hypothesis of no cointegration across all alternative assumption tests, even when accounting for a potential break. The results for the Gregory Hansen's test did not align with Kumar, Webber, and Perry (2012), who identified a structural break using the same GH test. The Gregory and Hansen Structural break and cointegration results are in Table 5 in the appendix.

4.3 Lag Order Selection

Having obtained all variables are stationary at first differences, the VECM model becomes appropriate for estimating the regression. Checking for the lag order selection criteria is important in choosing the optimal number of lags to include in the regression analysis. Among the various selection criteria, the Akaike Information Criterion (AIC) had the lowest value of –11.773 at lag 2, making it the optimal choice.[4] The Schwarz Bayesian Criterion (SBC) also indicated a maximum lag order of 2, in line with the AIC.

4.4 Johansen Test for Cointegration

I conducted the Johansen tests for cointegration to identify the number of cointegrating relationships among the key variables. Both the trace test and maximum eigenvalue test were conducted to evaluate the presence of cointegration

The Johansen Trace Test results provided evidence of one cointegrating relationship among the variables, indicated by the trace statistic at rank 0 exceeding the critical value, while at rank 1, the trace statistic falls below the critical threshold. At Rank 0 ($r = 0$), the trace statistic of 30.086 exceeds the critical value of 29.68 at the 5% level, allowing us to reject the null hypothesis of no cointegration. The result suggests at least one cointegrating relationship. At Rank 1 (r less 1), the trace statistic drops to 4.238, below the critical value of 15.41. The failure to reject the null hypothesis implies that only one cointegrating relationship exists, as indicated by the asterisk (*). [5] For Higher Ranks (r greater 2), trace statistics remain below critical values, confirming that there are no additional cointegrating relationships.

The Johansen Maximum Eigenvalue Test for Cointegration results indicate the presence of a single cointegrating relationship among the variables, supporting the findings of the Johansen Trace Test. With a rank 0 ($r = 0$), the max statistic of 25.847 exceeds the 5% critical value of 20.97, allowing rejection of the null hypothesis of no cointegration and indicating at least one cointegrating vector. Nevertheless, at rank 1 (r less 1), the max statistic dropping to 3.9867, below the critical value of 14.07, we fail to reject the hypothesis of only one cointegrating relationship, suggesting no further cointegration. Furthermore, higher ranks equal to or greater than 2 max statistics' remain below their critical values, reinforcing the conclusion of a single cointegrating vector.

4. Selection criteria result in Appendix Table 6.

5. Tables 7 and 8 in the appendix provide the test results, presenting both the trace and maximum eigenvalue statistics alongside their corresponding critical values for comparison.

4.5 Vector Error Correction Model Analysis

Consequently, I employed the Vector Error Correction Model (VECM) to regress wages and inflation on labor productivity. As the Gregory-Hansen test did not identify any cointegration among the variables, the Gregory-Hansen cointegration test was not pursued further. Instead, I utilized multiple regression analyses, including the Engle & Granger (EG) approach, Phillips Hansen Fully Modified OLS (FMOLS), Autoregressive Distributed Lag (ARDL), Dynamic Ordinary Least Squares (DOLS), and VECM to assess and compare the robustness of the findings. The results remained consistent across all econometric methods.

4.5.1 Long-Run Elasticities Analysis

The Johansen Normalization Restriction Imposed analysis presents the long-term equilibrium relationships among Productivity, Real Wage, and Inflation under a specified normalization. The coefficient of 0.406 for Real Wage suggests a positive long-term association with productivity. The standard error for this estimate is 0.051, and the associated z-score of -8.01 with a p-value of 0.000 indicates that the relationship is statistically significant at conventional levels. This could be interpreted as for each percentage increase in real wage, productivity increases by approximately 0.406% in the long run.

The coefficient of 0.116 for Inflation, with a standard error of 0.017, indicates a statistically significant positive relationship with productivity, as shown by the z-score of -6.88 and p-value of 0.000. This finding means that in the long run, for each percentage increase in Inflation, productivity increases by 0.116%. The confidence interval for inflation between (-0.149 and -0.083) reflects a narrow range, reinforcing the reliability of this estimate.

The constant term 3.451 represents a baseline level in the long-term equilibrium relationship. This term can be interpreted as the expected level of productivity when both real wage and inflation deviations are zero, under the assumption that the equilibrium relationship holds. [6] The VECM long-run cointegration equation was significant, with a chi-squared statistic of 65.88 and a p-value of 0.00, providing strong evidence of a long-run relationship among the variables. The estimated long-run equations for the cointegrating vector are presented below.

$$Productivty = 3.451 + 0.406 RealWage + 0.116 Inflation + \epsilon_t. \tag{5}$$

The results remained consistent across all econometric methods. These long-run findings are consistent across all estimation methods employed, with significance at the 5% level. The estimated wage elasticity ranges from 0.38 to 0.48, indicating that a 1% increase in real

6. Table 12 presents evidence of the robustness and significance of the long-run estimates.

manufacturing wages leads to a 0.38% to 0.46% rise in Canadian manufacturing productivity. Similarly, inflation elasticities are estimated between 0.0065% and 0.37%, suggesting that a 1% rise in inflation results in a 0.0065% to 0.37% increase in Canadian manufacturing productivity. These findings align with Mehra (1991), who also observed a positive long-run impact of inflation on productivity, supporting a long-run relationship between inflation and productivity in this study. The results of all estimators are presented in Table 9.

In the long run, the error correction term coefficient of the dynamic adjustment equation was only significant for the production equation but insignificant for both real wage and inflation. The study found that the error correction term in the production indicates approximately 8.38% of the deviation from the long-run equilibrium is corrected in the subsequent period. On the other hand, the coefficient for real wage in the error correction term is -0.0053 (not significant), suggesting that real wages do not respond significantly to long-term disequilibrium in the model. Also, the error correction coefficient for inflation is 0.1604 (not significant), which is positive and indicates no significant convergence towards the equilibrium.

4.5.2 Short-Run Elasticities Analysis

In the short-run, the Lagged Differenced Variables represent short-run effects, showing how previous changes in one variable affect the current values of the others. Given the short-run dynamics of productivity equation, both lagged real wage and lagged inflation with coefficients of -0.0005 and 0.0091 are not significant at $p < 0.05$. In the short-run dynamics of real wage equation, the lagged productivity coefficient of -0.2034 is not significant at $p < 0.05$, indicating that past changes in productivity do not significantly influence real wages in the short term. Nevertheless, the lagged inflation coefficient is -0.2508 (significant at $p < 0.05$), suggesting a short-run effect of past inflation on real wages. Inversely, the short-run dynamics of inflations equation, the lagged real wage coefficient of 1.8815 (significant at $p < 0.05$) suggests a strong impact of past real wage changes on inflation while lagged productivity does not.

In summary, the short run results found real wages significant in the inflation equation at a 5% significance level. Also, inflation is significant in the real wage equation at a 5% significance level. However, unlike Kumar, Webber, and Perry (2012), my results found real wage and productivity statistically insignificant in each other equation since their various P-values (0.446 and 0.989) are greater than the 5% significance level.

In conclusion, the analysis empirically reveals a significant positive impact on labor productivity from inflation and real wages, indicating that increases in these variables are associated with enhanced labor productivity. Only labor productivity indicates a significant adjustment toward long-run equilibrium.

4.6 Granger Causality

Wald causality test is deployed to examine whether one variable Granger causes another in the short term. This test is based on the null hypothesis that the coefficients of the lagged values of the independent variable are not significantly different from zero. The alternative hypothesis posits that at least one of the coefficients of the lagged values of the independent variable is significantly different from zero. The Wald test results report evidence of Granger causality between some of the variables in the short term. Specifically, lagged real wages exhibit p-values of 0.00 in the inflation equation, indicating a strong influence of past real wages on current inflation. Additionally, lagged inflation shows a p-value of 0.0007 in the real wage equation, suggesting that past inflation significantly affects current real wages.

In conclusion, the findings indicate a close short-run relationship between inflation rate and real wage growth, with evidence of a two-way directional causality between these two variables. However, labor productivity does not appear to significantly impact either real wages or inflation.

The coefficients of the lagged error correction terms derived from equations 2, 3, and 4 are used to assess the long-run causal effects. As shown in the VECM results in Tables 11, 12 and, 13, the error correction term for labor productivity is negative (-0.0838) with a p-value of 0.00, indicating statistical significance and suggesting that deviations from long-run equilibrium are corrected over time. However, no statistically significant error correction terms were found for real wages and inflation in the long run. This implies that labor productivity is influenced by deviations in real wages and inflation, but the reverse is not true for inflation and real wages.

4.7 Lagrange Multiplier and Eigenvalue Stability Tests

The Lagrange Multiplier test was conducted to check for the presence of autocorrelation in the residuals at different lag orders.[7] The null hypothesis assumes no autocorrelation at the given lag orders. The Chi-squared statistics for both lag 1 and 2 were 10.294 and 7.377, respectively, with corresponding p-values greater than the 5% significance level. Therefore, I fail to reject the null hypothesis, indicating no significant autocorrelation at either lag. This implies that the model error terms are well-behaved with respect to autocorrelation.

7. Tables 15 and 16 present the results of the Lagrange Multiplier and Eigenvalue Stability test.

The Eigenvalue stability test was also conducted to examine the stability of the studies' Vector Error Correction Model (VECM). To confirm that VECM is suitable for this framework, the modulus of each Eigenvalue must be between zero (0) and one (1), with unit moduli permissible in the case of cointegration. The Eigenvalue test reveals that the model satisfies the stability condition as the modulus values are within the acceptable ranges.

4.8 Results Comparison

Kumar et al. studied the "Real wage, inflation, and labor productivity in Australia," exploring the relationships among the variables using similar econometric techniques, including VECM, cointegration analysis, and causality tests. Both studies utilize a VECM framework, cointegration analysis, and Granger causality tests. By applying Gregory Hansen (GH) test, Kumar et al. (2012) found evidence of cointegration in the structural break. However, this study's GH test found no evidence of the presence of cointegration in the structural break. Additionally, the geographic context differs, with Kumar et al. focusing on Australia, whereas my study uses a Canadian dataset, potentially reflecting structural differences in both economies.

In the long-run dynamics, Kumar et al. (2012) found a long-run relationship between real wages, inflation, and productivity, highlighting long-run Granger causality from inflation and real wage to productivity. Similarly, this study identified cointegration between productivity, real wages, and inflation, where real wages and CPI exert significant long-run effects on labor productivity. The study also found evidence of a long-run Granger causality from inflation and real wages. Contrary to Kumar et al. (2012), who empirically emphasized that real wages positively affect productivity, while inflation has a relatively weak negative effect on productivity. My study revealed that both real wages and inflation positively impact productivity. The difference in the inflation coefficient for both studies could be attributed to the heterogeneous nature of the economics in these two countries.

Both studies identified a short-run Granger causality among some of the variables. This paper's result found the existence of a bidirectional causality between inflation and real wages but failed to accept that labor productivity does not significantly influence real wages or inflation in the short run. On the other hand, Kumar et al.'s (2012) Granger causality test found a bidirectional causality between productivity and real wages.

5 Conclusion

The influence of real wages and inflation rate on labor productivity is highly debated in economics. Multiple researchers have empirically shown that real wages directly affect productivity positively, whereas the rate of inflation inversely impacts productivity. Limited studies found evidence supporting the positive direct influence of the inflation rate on productivity. This paper uses time series data to examine the interrelationships among inflation rate, real wages, and labor productivity, adapting the framework of Kumar et al. (2012) to the Canadian context. The Vector Error Correction Model (VECM) and other econometric estimation techniques are explored to determine the short and long-run behavior of the key variables. Monthly data on real wages, inflation rate, and labor productivity, collected from Statistics Canada CANSIM over the period 2000 to 2023, were used.

Despite several research papers showing that real wages positively affect productivity while inflation negatively does, this research partially agreed with Kumar et al.'s (2012) findings. My main finding empirically reveals that inflation rate and real wages positively contribute to labor productivity in the long run. Thus, a 1% increase in real wage increases labor productivity by 0.406%, while a 1% rise in inflation rate surges labor productivity by 0.115%. The empirical result is similar to all other estimation techniques used for this analysis. In the short run, I found a Granger causality between real wages and the inflation rate. This implies that the past values of inflation induce the current real wage while the current values of inflation are induced by the past value of inflation rate. Although this study's finding revealed a structure break in the Gregory Hansen test, there was no evidence to support the presence of cointegration in the structure break.

The study's findings reveal a positive long-run relationship between the inflation rate, real wages, and labor productivity. This suggests that both real wages and inflation play a significant role in driving labor productivity in Canada. Policymakers are encouraged to maintain the inflation rate at an optimal level to maximize productivity in the long-run equilibrium. Additionally, setting real wages at a level that preserves labor's purchasing power could further enhance productivity. A key limitation of this study is that the analysis is confined to inflation rate, real wages, and productivity variables. Future research should consider incorporating additional variables, such as unemployment rates, interest rates, and other key macroeconomic indicators, to provide a more comprehensive analysis of the dynamics within the Canadian context.

6 Acknowledgment of AI Tool Usage

During the preparation of my thesis, I used OpenAI to strengthen my expressions and fix grammar errors. After using this tool, I reviewed and edited the content as needed and took full responsibility for its content.

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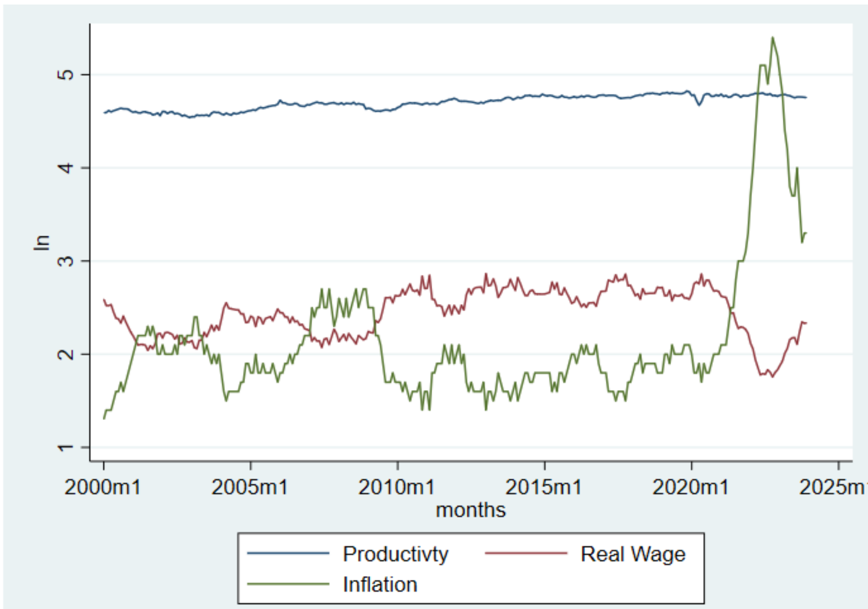
7 Appendix A: Tables and Graphs

Figure 1: Productivity, Real wage, and Inflation



Note: This graph shows the trends of productivity, real wages, and inflation from January 2000 to December 2023. The x-axis represents the natural log units while the y-axis is the months used for the purpose of this study.

Table 1: Summary of Variables and Notations

Notation	Variable Name	Description
Y_t	Productivity	Gross Domestic Product at basic price by Industry at time t.
W_t	Real Wage	Employee wage adjusted for Inflation by Industry t
π_t	Inflation Rate	Monthly inflation rate at time t
X_t	Employment Rate	Employment by Industry at time t
Δy_{it}	Dependent Variable in First Differences	The change in the variable y_{it} over time
ϕy_{it-1}	Lagged Dependent Variable	The lagged value of the dependent variable y_{it}
κ_i	Constant Term	The constant term in the model
$\sum_{j=1}^{k} \delta_{ij}$	Summation over Lags of Differenced Variables	Summation over the lags of differenced variables in the model
$\hat{\gamma}$	Estimated Coefficient of y_{t-1}	The estimated coefficient of the lagged dependent variable y_{t-1}
SE($\hat{\gamma}$)	Standard Error of Estimate	The standard error of the estimated coefficient $\hat{\gamma}$
ECT_{t-1}	Long-Run Cointegrating Vector Error	The error correction term capturing deviations from the long-term equilibrium
ϵ	Residual Term	The residual term in the model

Notes: The notations above and their corresponding variable names are the key notations used in this study.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ln Real Wage	288	2.4430	0.2570	1.7570	2.8650
ln Productivity	288	4.7020	0.0760	4.5390	4.8240
Inflation	288	2.1510	0.7740	1.3000	5.4000
ln Inflation	288	0.7200	0.2790	0.2620	1.6860

Notes: This table presents the descriptive statistics for key variables used in the analysis, providing an overview of their distributional properties across the sample of 288 observations. Data were derived from Statistics Canada-Cansim.

Table 3: Results of Augmented Dickey-Fuller Unit Root Tests

Individual Intercept				
Variable	Level		First Difference	
	Test Statistic	Probability	Test Statistic	Probability
ln Productivity	-3.3330	0.0610	-17.6610*	0.0000
ln Real Wage	-2.2210	0.4780	-20.3250*	0.0000
Inflation	-1.5700	0.8040	-16.4200*	0.0000

Notes: The null hypothesis is that the series is non-stationary or contains a unit root. The lag length is selected based on the Akaike info criterion. *significant at 5% level. The ADF critical values are at the 5% level.

Table 4: Results of Philips-Perron Unit Root Tests

Individual Intercept				
Variable	Level		First Difference	
	Test Statistic	Probability	Test Statistic	Probability
ln Productivity	-3.1760	0.0894	-17.9060*	0.0000
ln Real Wage	-2.2590	0.4569	-20.0030*	0.0000
Inflation	-1.9750	0.6152	-16.7570*	0.0000

Notes: The null hypothesis is that the series is non-stationary or contains a unit root. The lag length is selected based on the Akaike info criterion. *significant at 5% level. The PP critical values are at the 5% level.

Table 5: Cointegration Tests with Structural Breaks for the Period 2000 to 2023

Model	Break date	GH test statistic	5% critical value	Evidence of cointegration
1	2013m10	-4.2100	-4.9200	No
2	2020m5	-4.4600	-5.2900	No
3	2013m6	-4.5500	-5.5000	No
4	2005m1	-5.0000	-5.9600	No

Notes: Model (1) is the level shift. Model (2) is a level shift with a trend. Model (3) is a regime shift where intercept and slope coefficients change. Model (4) is a regime shift where intercept, trend, and slope coefficients change.

Table 6: Selection-Order Criteria

Lag	LL	LR	DF	P	FPE	AIC	HQIC	SBIC
0	288.1400				1.5e-05	-2.0080	-1.9930	-1.9690
1	1657.3100	2738.3000	9	0.0000	1.9e-09	-11.5870	-11.5250	-11.4330
2	1692.7200	70.8280	9	0.0000	1.5e-09*	-11.7730*	-11.6650*	-11.5030*
3	1697.9700	10.4880	9	0.3120	1.6e-09	-11.7460	-11.5920	-11.3610
4	1708.3400	20.7520*	9	0.0140	1.6e-09	-11.7556	-11.5550	-11.2550

Notes: Sample size spanning from May 2000 to December 2023 with estimated 284 observations. The minimum value criteria with asterisk is selected for this test. LL, LR, df, p, FPE, AIC, HQIC, and SBIC represent the Log-Likelihood, Likelihood Ratio, Degrees of Freedom, p-value, Final Prediction Error, Akaike Information Criterion, Hannan-Quinn Information Criterion, and Schwarz-Bayesian Information Criterion, respectively.

Table 7: Johansen Trace Test for Cointegration

Rank	Parameters	LL	Eigenvalue	Trace Statistic	5% Critical Value
0	3	1661.8590	-	30.0860	29.6800
1	8	1674.7820	0.0861	4.2380*	15.4100
2	11	1676.7760	0.0138	0.2520	3.7600
3	12	1676.9010	0.0009	-	-

Notes: The Johansen trace test statistic which is below the 5% critical value of 15.41. This suggests that we fail to reject the null hypothesis at rank 1, indicating no more than one cointegrating relationship. This is indicated by the asterisk (*) at rank 1. LL represents the Log-Likelihood while parms is the parameters estimated.

Table 8: Johansen Maximum Eigenvalue Test for Cointegration

Rank	Parameters	LL	Eigenvalue	Max Statistic	5% Critical Value
0	3	1661.8590	-	25.8470	20.9700
1	8	1674.7820	0.0861	3.9870	14.0700
2	11	1676.7760	0.0138	0.2520	3.7600
3	12	1676.9010	0.0009	-	-

Notes: The maximum eigenvalue test compares the null hypothesis of exactly rank cointegrating vectors against the alternative hypothesis of rank + 1 cointegrating vectors. The test also confirms one cointegrating relationship. LL represents the Log-Likelihood while parms is the parameters estimated.

Table 9: Alternative Long-Run Estimates

	EG	FMOLS	DOLS	ARDL	VECM
Constant	3.4190	3.3250	3.3450	0.3140	3.4510
	(87.3800)*	(25.1900)*	(51.6700)*	(3.8100)*	(-)*
Real Wage	0.4170	0.3870	0.4590	0.4310	0.4060
	(31.9400)*	(9.2500)*	(21.6600)*	(6.5900)*	(-8.0100)*
Inflation	0.3670	0.0650	0.2880	0.3430	0.1150
	(30.6200)*	(2.3500)*	(10.6200)*	(7.7500)*	(-6.8800)*

Notes: In all cases, the dependent variable is productivity. The absolute t-ratios are given within parentheses. * Denotes significance at the 5% level. '–' indicates estimate not available. The estimation methods used in this analysis are Engle-Granger (EG), Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), Autoregressive Distributed Lag Model (ARDL), and Vector Error Correction Model (VECM).

Table 10: Results of Granger Causality Test

Dependent variable	Δ Productivity (t)	Δ Real Wage (t)	Δ Inflation (t)	ECT_{t-1}
Δ Productivity (t)	–	-0.0005	0.0091	-0.0838
	–	(-0.0100)***	(0.5600)***	(-4.0900)*
Δ Real Wage (t)	-0.2034	–	-0.2508	-0.0053
	(-0.7600)***	–	(3.3800)*	(-0.0600)***
Δ Inflation (t)	0.4636	1.8815	–	0.1605
	(0.8200)***	(5.5400)*	–	(0.8400)***

Notes: Each cell represents the coefficient for the independent variable column when explaining the dependent variable row. The t-ratios are given within parentheses. * Denotes significance at the 5% level. *** Denotes insignificance at the 5% level. Δ represents a change in a variable at time t.

Table 11: Vector Error Correction Models (2000M3 – 2023M12)

	Dependent variable		
Regressor	Diff. Productivity	Diff. Real Wage	Diff. Inflation
Lagged Error Correction Term	-0.0838*	-0.0053	0.1604
	(0.0204)	(0.0936)	(0.1989)
Lagged Diff. Productivity	-0.0180	-0.2034	0.4636
	(0.0584)	(0.2669)	(0.5672)
Lagged Diff. Real Wage	-0.0005	-0.6918*	1.8815*
	(0.0350)	(0.1599)	(0.3399)
Lagged Diff. Inflation	0.0090	-0.2508*	0.8274*
	(0.0162)	(0.0742)	(0.1576)
Constant	-0.0013	0.0006	0.0007
	(0.0008)	(0.0038)	(0.0080)
R-squared	0.0610	0.0740	0.1030
Chi Square	18.2270	22.3010	32.2340
P > Chi Square	0.0030	0.0010	0.0000

Notes: Standard errors are in the parenthesis. The numbers with asterisks indicate the variables are significant at $*p < 0.05$. Diff represents Differenced. This table summarizes the results of a Vector Error Correction Model (VECM), which examines the relationships among the variables

Table 12: Cointegrating Equations Summary

Cointegrating Equation	Parms	Chi-squared	P>Chi-squared
Lagged Error Correction Term	2	65.8860	0.0000

Notes: The table examined the significance of a lagged error correction term in the model, which helps understand long-term equilibrium relationships between variables in the models. Beta is exactly identified.

Table 13: Johansen Normalization Restriction Imposed

Beta	Coefficients	Standard Errors	z	P> $\lvert z \rvert$	95% Confidence. Interval	
Productivity	1	-	-	-	-	-
Real Wage	0.4060	0.0510	-8.0100	0.0000	-0.5050	-0.3070
Inflation	0.1160	0.0170	-6.8800	0.0000	-0.1490	-0.0830
Constant	3.4510	-	-	-	-	-

Notes: The table shows the coefficients that describe the long-term relationships among productivity, real wage, and inflation under the normalization restriction. Although the coefficients have negative signs in the Stata output, they are written and interpreted as indicating a positive relationship.

Table 14: Wald Test Results for Short Run Granger Causality

Test	Chi-squared	Prob > Chi-squared
Differenced Productivity: Lagged First Difference of Real Wage	0.0000	0.9890
Differenced Productivity: Lagged First Difference of Inflation	0.3100	0.5750
Differenced Productivity: Lagged First Difference of Productivity	0.0900	0.7580
Differenced Inflation: Lagged First Difference of Productivity	0.6700	0.4140
Differenced Inflation: Lagged First Difference of Real Wage	30.6400	0.0000
Differenced Inflation: Lagged First Difference of Inflation	27.5600	0.0000
Differenced Real Wage: Lagged First Difference of Inflation	11.4400	0.0010
Differenced Real Wage: Lagged First Difference of Productivity	0.5800	0.4460
Differenced Real Wage: Lagged First Difference of Real Wage	18.7200	0.0000

Notes: This identifies the specific test performed, showing the dependent variables (Productivity, Inflation, and Real Wage) being tested against the lagged differences of these same variables. It also presents the short-term Wald test for Granger causality, the chi-squared statistics, and their corresponding p-values.

Table 15: Lagrange-Multiplier Test

Lag	Chi2	df	Prob > Chi2
1	10.2940	9	0.3270
2	7.3770	9	0.5980

Notes: This table shows the results of a Lagrange-multiplier (LM) test for autocorrelation in a time series model. The results of the LM test suggest no significant autocorrelation at either lag 1 or lag 2, as indicated by the high p-values.

Table 16: Eigenvalue Stability Condition

Eigenvalue	Modulus
1	1
1	1
0.9010	0.9010
0.3960	0.3960
-0.2670	0.2670
-0.0130	0.0130

Notes: The stability of a VECM is determined by the modulus of its eigenvalues. A modulus equal to or less than 1 indicates stability, while values greater than 1 would imply instability. The VECM specification imposes 2 unit moduli.