Public Investment, Private Investment, and Labor Productivity in Nepal: A Cointegration and VECM Analysis

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Abstract

The main objective of this paper is to analyze the impact of public and private investment on labor productivity in Nepal using time series data from 1991-2021. By employing the Zivot-Andrews single break unit root test and Johansen cointegration analysis, a long-run stable relationship is found among public investment, private investment, and labor productivity. A VECM model is estimated to find that both public and private investment have a positive impact on labor productivity with a more significant and strong impact coming from the private investment in the long run. The nature of labor productivity and public investment is found to be endogenous and that of private investment is found to be weakly exogenous. Additionally, a Granger Causality Test is performed and the result shows that labor productivity and private investment cause public investment. To test the causation from public investment to labor productivity, a Pairwise Granger Causality Test is done and it is found that public investment causes labor productivity only at lags of 4 and 5 which confirms that public investment takes time to impact the labor market conditions. Policy implications are discussed.

Keywords: Cointegration analysis, Vector error correction model, Granger block causality, Public investment, Zivot-Andrews test

JEL codes: C22, H54, O53

1. Introduction

Economic theory suggests that investment has a big impact on labor productivity and the overall economic growth of a country. Broadly, there are two types of investments – public and private. Public investments are the investments made by the government that mostly happen in sectors of national importance like infrastructure, education, health etc. Private investments are the investments from the private sector which are mostly motivated by profit opportunities for the private entity which generally trickles down to create an overall impact on the economy. Public and private investments can sometimes be complements and sometimes be substitutes. So, it is highly necessary to have a better understanding of the impact private and public investments have on labor productivity before making many national-level policy decisions.

Development economists consider labor productivity as one of the major factors that impact the long-run economic growth of a country. Studies have shown that human capital accumulation and economic growth are intimately related (Topel, 1999). Other studies have shown that investments are mostly associated with technological progress which indeed raises labor productivity (Grazzi, Jacoby & Treibich, 2016). In that regard, it is evident that most developing countries do not have high labor productivity due to lack of skilled workers and lack of technological progress. The investments that the government and the private sector make in developing countries are theoretically supposed to increase the productivity of labor, but this has not always been the case. Studies have shown that there are other factors like infrastructure governance and changes in workforce demographics that determine the effectiveness of public investment in raising labor productivity and overall economic growth (Miyamoto et al., 2020; Vandenbroucke, 2017). So, the dynamics of labor productivity is mostly driven by investments but have other secondary factors like infrastructure governance and demographics impacting it. Considering this, we chose to study the primary factors that impact labor productivity - public and private investments.

Most studies that have been done on the impact of public and private investment spending on labor productivity are focused on advanced economies or regions (high-income countries or sectors). There are only a few studies focused on country-level analysis for developing countries and there is none for Nepal. For a developing country like Nepal, it is highly important to understand and quantify the impact of public and private investments to create more focused policies that will help bring in more investment into the country and contribute to increasing labor productivity. The lack of any study on the impact of public and private investment on labor productivity in Nepal motivated us to base our study on Nepal.

In this paper, we aim to investigate the relationship among public investment, private investment, and labor productivity in Nepal. The aim of the paper is also to understand if public investment and private investment have actually helped raise labor productivity or not in the case of Nepal using time series data from 1991 to 2021.

This paper will use the Johansen procedure to check for potential cointegration and will also estimate a Vector Error Correction Model (VECM) to look into endogeneity problems and find speeds of adjustments for the three variables that track public investment, private investment, and labor productivity. Since this is the first study done on the topic for Nepal, the paper will contribute firstly by establishing a cointegrating relationship among public investment, private investment, and labor productivity in Nepal. Secondly, the paper will quantify the impact of public and private investment on labor productivity in Nepal and contribute by identifying what type of investment has a higher impact and with what number of lags. This is very important to understand as developing countries mostly face the dilemma of choosing between public and private investment on many small to medium-scale projects.

The remainder of the paper is structured in the following manner: Section II provides a review of the existing literature pertaining to related subjects. Section III outlines the empirical model, while Section IV elaborates on the utilized data. Section V delves into the empirical findings. Section VI briefly addresses Granger Causality/Block Exogeneity tests, aiming to ascertain the direction of causation and the associated time lags. The final section provides concluding remarks, major takeaways, limitations, and policy implications.

2. Literature Review

According to macroeconomic theory, public investment stimulates economic activity through short-term effects on aggregate demand which raises the productivity of existing private capital. Several studies have shown that public investment encourages new private investment to take advantage of the higher productivity it creates (Barro, 1990; Glomm and Ravikumar, 1994; Turnovsky, 1997). Aschauer (1989) found that public investment had positive direct and indirect effects on private sector output and productivity for G-7 industrial economies. Aschauer (1989) in his other paper, found that a one percent increase in public investment leads to a 0.27 percent increase in labor productivity in the US, while private investment was found to have a smaller impact in the US for the period 1949-1985.

Ramirez (2000) studied the impact of public and private investment spending on the rate of productivity growth in Chile during the 1960-1995 period and found both public and private investment spending to have positive and significant effects. Furthermore, Herranz-Loncan (2007) studied the role of public investment in Spain's economy and found that public investment in infrastructure had a positive impact on GDP per capita growth and labor productivity growth in Spain. The author also argued that public investment in infrastructure facilitated the development of new industries and increased the connectivity of different regions of Spain. Likewise, Ramirez (2009) studied the role of public infrastructure investment in Argentina during 1960-2005 and found that public infrastructure investment, as opposed to overall public investment, had a positive effect on the rate of labor productivity growth in Argentina.

Moreover, Ngyun and Trin (2018) conducted a study on the effect of public investment on private investment and economic growth in Vietnam using data for 1990-2016 and found an inverted U relationship suggesting that public investment crowds in private investment in the short-run but crowds it out in the long-run. This study shows the variability of the impact of public investment in many countries which motivates this paper to investigate the case for Nepal.

Chatterjee, Lebesmuehlbacher, and Narayanan (2021) studied the impact that government investment in public infrastructure creates in formal and informal production in India. They find that public capital investments create positive and significant output elasticity in formal production firms in India but don't have any major effect on informal production firms. They specifically found that proximity to newly completed highways and time since project completion are productivity-enhancing for formal firms. There has not been any particular study done on how public and private investment has impacted labor productivity in Nepal. So, this paper is a new addition to the literature.

3. Empirical Model

The objective of this study is to examine the relationship between public investment, private investment, and labor productivity in Nepal over the period from 1991 to 2021. The research employs a single break unit test and Johansen cointegration analysis to explore the presence of a consistent, long-term relationship among the three variables: *logPROD*, *logPUB* and *logPRIV.* Subsequently, a VECM model is generated including the three dummy variables to obtain adjustment speeds and investigate the endogeneity and exogeneity of the variables. The general VECM model is mentioned below:

$$\Delta logPROD_{1t} = a_{10} + \sum_{i=1}^{p} a_{11}\Delta logPROD_{1t-i} + \sum_{i=1}^{p} a_{12}\Delta logPUB_{1t-i} + \sum_{i=1}^{p} a_{13}\Delta logPRIV_{1t-i} + a_{14}D_1 + a_{15}D_2 + a_{16}D3 + \lambda_1 ECT_{t-1} + \mu_{1t}$$

$$\Delta logPUB_{2t} = a_{20} + \sum_{i=1}^{p} a_{21}\Delta logPROD_{2t-i} + \sum_{i=1}^{p} a_{22}\Delta logPUB_{2t-i} + \sum_{i=1}^{p} a_{23}\Delta logPRIV_{2t-i} + a_{24}D_1 + a_{25}D_2 + a_{26}D3 + \lambda_2 ECT_{t-1} + \mu_{2t}$$

$$\Delta logPRIV_{3t} = a_{30} + \sum_{i=1}^{p} a_{31}\Delta logPROD_{3t-i} + \sum_{i=1}^{p} a_{32}\Delta logPUB_{3t-i} + \sum_{i=1}^{p} a_{33}\Delta logPRIV_{3t-i} + a_{34}D_1 + a_{35}D_2 + a_{36}D3 + \lambda_3 ECT_{t-1} + \mu_{3t}$$

Where *logPROD* refers to the log of GDP per person employed in constant 2017 PPP dollars, *logPRIV* refers to the log of Gross Fixed Capital Formation from the private sector in constant 2017 PPP dollars, and *logPUB* refers to the log of difference between Gross Fixed Capital Formation and Gross Fixed Capital Formation from private sector in constant 2017 PPP dollars which is used as a proxy series for public investment. All data is obtained from the World Development Indicators (WDI) Database of the World Bank.

4. Data

Within a VEC model, it is assumed that all three variables are of endogenous nature. Logarithmic transformation is done for all the variables which makes them easy to interpret. *logPROD* refers to the log of GDP (Gross Domestic Product) per person employed in constant 2017 PPP dollars. *logPROD* represents labor productivity in the model.

logPRIV refers to the log of Gross Fixed Capital Formation from the private sector in constant 2017 PPP dollars. Initially, the Gross Fixed Capital Formation from the private sector was extracted as % of GDP and then it was converted to number form by using the value of GDP (in constant 2017 PPP dollars). *logPRIV* represents private investment in the model.

The difference between Gross Fixed Capital Formation and Gross Fixed Capital Formation from the private sector was taken to get a crude estimate of domestic investment. Firstly, it was calculated as % of GDP. Then, it was transformed to numerical value using the value of GDP (in constant 2017 PPP dollars). So, *logPUB* refers to the log of the difference between Gross Fixed Capital Formation and Gross Fixed Capital Formation from the private sector. *logPUB* represents a crude estimate for public investment in the model.

In the VEC model, dummy variables D1, D2, and D3 are introduced to account for the structural breaks identified in the dataset. D1 represents the period of the civil war that affected the Nepalese economy, spanning from 1996 to 2006. D2 accommodates the impact of the significant earthquake that occurred in Nepal in 2015, which led to disruptions in investment and labor productivity. D3 accommodates for the shock caused in the investment coming to Nepal by the COVID pandemic in 2020 and 2021.

The anticipated relationship between *logPROD* and *logPUB* is positive, as it is commonly held that an upsurge in public investment within the economic system would augment the pool of capital resources available to both existing and new workers, consequently enhancing labor productivity. Likewise, *logPROD* and *logPRIV* are also anticipated to have a positive relationship. But, there can also be instances where public investment can crowd out private investment by increasing the real interest rate. The increment in the interest rate discourages private investment. Such crowding out of private investment might decrease the labor productivity of the nation. In the case of Nepal, we can hypothesize that *logPROD* and *logPRIV* have a positive relationship.

Dummy variable D1 is anticipated to have a negative relationship with *logPROD.* A negative effect on *logPRIV* is also anticipated because private companies would not want to invest in Nepal during times of political conflict and uncertainty.

It is expected that Dummy variable D2 will exhibit a negative association with *logPROD* because many factories were devastated by the earthquake which lowered the factory output. D2 is also expected to have a negative impact on *logPRIV* as private companies reconsidered their immediate investment plans due to the earthquake.

Dummy variable D3 is anticipated to negatively affect *logPROD* because a pandemic is expected to reduce or slow down the growth rate of GDP which would decrease *logPROD.* It is also expected to have a negative impact on *logPRIV* because private companies would not think of expanding or investing more money during a pandemic.

5. Estimation Results

5.1 Testing for Stationarity

When working with macroeconomic data, evaluating the stationarity of the data is of utmost significance as most macroeconomic variables are found to have unit roots. If a regression is run with non-stationary data then the regression will be spurious and the estimates will not be useful. Many different unit root tests are undertaken for all three variables in their log form: *logPROD, logPUB, logPRIV.* First, the variables are plotted in both level form and first difference form to perform preliminary analysis. Then, the Augmented Dickey Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Lagrange Multiplier, Phillips-Perron (PP), Zivot-Andrews Single Break unit root tests are conducted to determine the order of integration of the three time series variables.

5.1.1 Graphical Analysis

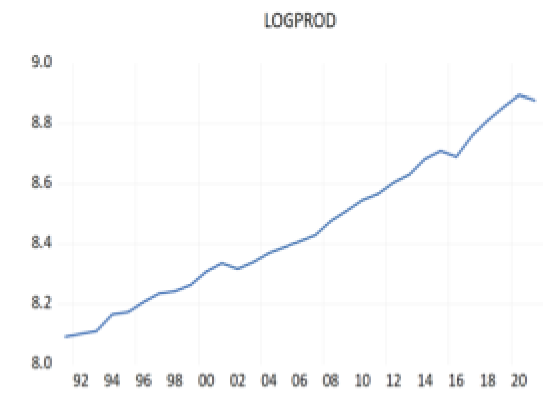

Figure 1.

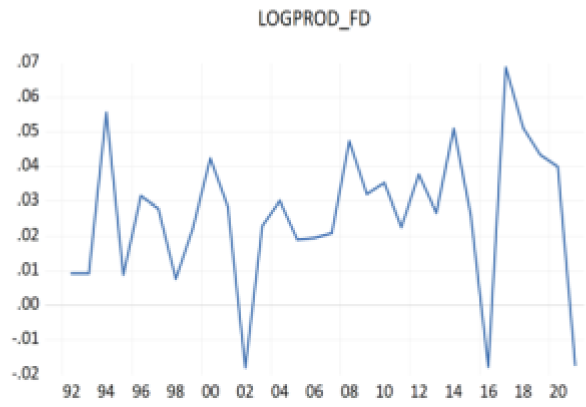

Figure 2.

Figures 1 and 2 in the Appendix below illustrate the log transformation of GDP per person employed (*logPROD*) presented in both its original level and first difference forms. In its original level form, *logPROD* displays features of a random walk with a positive drift and a deterministic trend, which implies that the mean is not constant. Hence, *logPROD* appears to be non-stationary when presented in its original level form. When *logPROD* is graphed in its first difference form, it becomes evident that stationarity is achieved, as there appears to be a consistent long-term mean to which the series returns. In the first difference form, a notable structural break is observed during the period of 2001-2002. This is due to the escalation of the civil war during that period and also the Royal Massacre of June 2001. Both of these factors had an adverse effect on GDP per person employed. From the graph, it looks like there are two other structural breaks, one in 2015 and one in 2020-21. The one in 2015 is due to the massive earthquake that Nepal experienced and the one in 2020-21 is because of the COVID pandemic. Both of these breaks had a negative impact on GDP per person employed.

In the graph of *logPUB* presented in its original level form, the series appears to resemble a random walk with neither a drift nor a deterministic trend. Nonetheless, when viewed in its first difference form, the series appears to exhibit stationarity, with a consistent long-term mean in place. In both level form and first difference form, we can see a decreasing slope in the graph during the 2000-2001 period which is also due to the political unrest caused by the

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Maoist War against the government. The graphs in both level and first difference form are shown in Figures 3 and 4 respectively in the Appendix below.

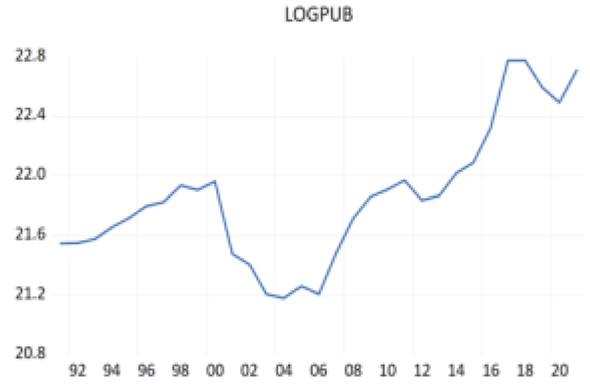

Figure 3.

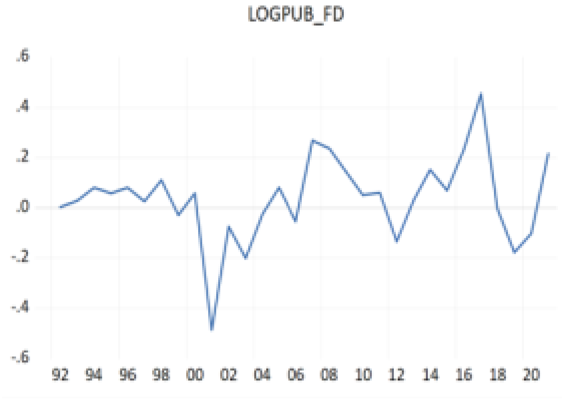

Figure 4.

Finally, the graph of *logPRIV* appears to follow a random walk pattern with both a positive trend and a deterministic component. Hence, when presented in its original level form, *logPRIV* appears to be non-stationary. In its first difference form, the series appears to exhibit stationarity, as it appears to return to a consistent long-term mean. In the first difference form, it appears that a structural break occurred in 2019-2020, which could be attributed to the impact of the COVID-19 pandemic. Surprisingly, there seems to be a growth in private investment right before the Royal Massacre of 2001. The graphs in both level and first difference form are shown in Figures 5 and 6 respectively in the Appendix below.

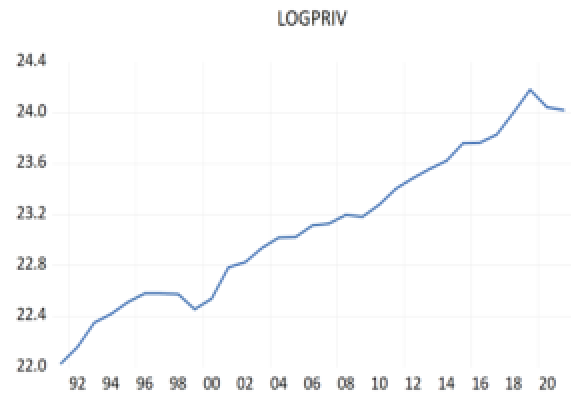

Figure 5.

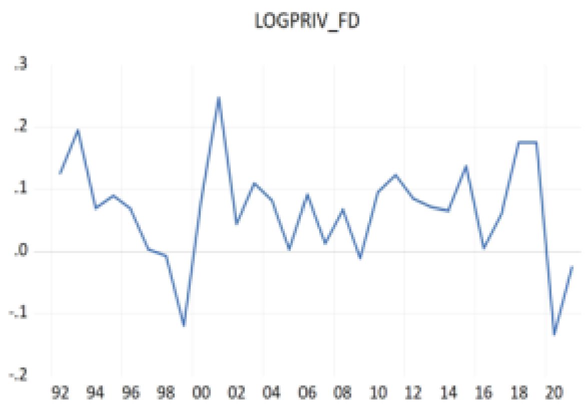

Figure 6.

Table 1. Summary of statistics from all unit root tests

	Level Data			
	ADF	KPSS	PP	ZA
logPROD	-2.144 (0.502)	0.182	-2.130 (0.509)	-4.908
logPUB	-1.178 (0.897)	0.152	-1.365 (0.851)	-5.233
logPRIV	-3.504 (0.058)	0.107	-2.926 (0.169)	-4.595
	ADF and PP test critical values: -4.297 (1%), -3.568 (5%), -3.218 (10%)			
	KPSS critical values: 0.216 (1%), 0.146 (5%), 0.119 (10%)			
	Zivot-Andrews test critical values: -5.57 (1%), -5.08 (5%), -4.82 (10%)			
	(p-values in parentheses), significance of 5%			
	First Differenced Data			
	ADF	KPSS	PP	ZA
logPROD	-5.109 (0.002)	0.249	-9.558 (0.000)	-5.642
logPUB	-3.774 (0.001)	0.069	-3.765 (0.001)	-4.665
logPRIV	-4.481 (0.007)	0.149	-4.609 (0.005)	-45.425
	ADF test critical values with trend and intercept: -4.297 (1%), -3.568 (5%), -3.218 (10%)			
	PP test critical values: -4.309 (1%), -3.574 (5%), -3.222 (10%)			
	KPSS critical values with intercept: 0.739 (1%), 0.463 (5%), 0.347 (10%)			
	Zivot-Andrews test critical values: -5.57 (1%), -5.08 (5%), -4.82 (10%)			
	AD test critical values with no trend but intercept: -2.647 (1%), -1.953 (5%), -1.610 (10%)			
	KPSS critical values with trend and intercept: 0.216 (1%), 0.146 (5%), 0.119 (10%)			
	(p-values in parentheses), significance of 5%			

5.1.2 Augmented-Dickey Fuller (ADF) Test

Table 1 presents the results of ADF tests conducted on all three time series. These tests serve to formally assess the stationarity of the series and determine their order of integration. The tests are carried out in accordance with the Dolado-Sosvilla-Rivero methodology, which recommends initially testing the most unrestricted model (the one with trend and intercept). ADF tests have low power, so the results of the ADF test will be compared with the results of other more powerful tests like the PP test to confirm the order of integration.

In the case of *logPROD* presented in its original level form with both a constant and trend, the ADF t-statistic yields a p-value of 0.502. As a result, the null hypothesis, which suggests the existence of a unit root in the level form, cannot be rejected at a 5% significance level. Therefore, based on the ADF test, we can conclude that *logPROD* exhibits non-stationarity in its original level form. Upon first differencing *logPROD* and conducting the ADF test with both a constant and trend, the resulting ADF t-statistic yields a p-value of 0.002. This implies that *logPROD* is stationary in its first difference form, leading to the conclusion that *logPROD* is integrated of order 1 (I(1)).

In the case of *logPUB* presented in its original level form with both a constant and trend, the ADF t-statistic yields a p-value of 0.897. Consequently, the null hypothesis of a unit root in the level form cannot be rejected at a 5% significance level. Therefore, we can infer that *logPUB* lacks stationarity in its original level form based on the ADF test. However, when *logPUB* is subjected to a first-difference transformation, and the ADF test is applied without a constant and trend, the ADF t-statistic results in a p-value of 0.001. This indicates that *logPUB* is stationary in its first difference form, leading to the conclusion that *logPUB* is integrated of order 1 (I(1)).

Finally, in the case of *logPRIV* presented in its original level form with both a constant and trend, the ADF t-statistic yields a p-value of 0.058. As a result, the null hypothesis of a unit root in the level form cannot be rejected at a 5% significance level. Consequently, we can assert that *logPRIV* lacks stationarity in its original level form according to the ADF test. However, when *logPRIV* is subjected to a first-difference transformation, and the ADF test is applied without a constant and trend, the ADF t-statistic yields a p-value of 0.007. This indicates that *logPRIV* is stationary in its first difference form, leading to the conclusion that *logPRIV* is integrated of order 1 (I(1). All of these results are presented in Table 1.

5.1.3 Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Lagrange Multiplier Test

The KPSS test is a more potent Lagrange Multiplier test intended to validate the outcomes of the ADF test. In the KPSS test, the null and alternative hypotheses are inverted. So, the rejection of null would mean that the series is non-stationary and failure to reject would mean that the series is stationary. The KPSS test is done for all three variables: *logPROD*, *logPUB* and *logPRIV*. The results are reported in Table 1.

For *logPROD* in level form, the KPSS stat is greater than the critical value at the 5 % level which makes us reject the null. This means that the *logPROD* is non-stationary at level form. KPSS test is again performed for *logPROD* in first difference form with only intercept in the model. The KPSS statistic is 0.249 which is lower than the critical value at the 5% level. This makes us not reject the null and conclude that *logPROD* is stationary in the first difference form, which is consistent with the ADF test results.

For *logPUB* in level form, the KPSS stat is greater than the critical value at the 5 % level which makes us reject the null. This means that the *logPUB* is non-stationary in level form. KPSS test is again performed for logPUB in first difference form with both trend and intercept in the model. The KPSS statistic is 0.069 which is lower than the critical value at the 5% level. This makes us not reject the null and conclude that *logPUB* is stationary in the first difference form, in line with the ADF test.

Finally, for *logPRIV* in level form, the KPSS stat is not greater than the critical value at the 5 % level which makes us not reject the null. This implies that *logPRIV* exhibits stationarity in its original level form. This outcome contradicts the finding from the ADF test. KPSS test is again performed for *logPRIV* in first difference form with only intercept in the model. The KPSS statistic is 0.149 which is lower than the critical value at the 5% level. This makes us not reject the null and conclude that *logPRIV* is stationary in the first difference form. Since, the result for level form using the KPSS test for *logPRIV* contradicts that of the ADF test, we will use a more powerful PP test to have a solid conclusion regarding the order of integration of *logPRIV* later in the paper.

5.1.4 Phillips-Perron (PP) Test

The Phillips-Perron (PP) test is the most powerful of all the tests used in this paper to investigate the order of integration of time series variables. So, the result of the PP test is given the highest importance in deciding the order of integration of the variables used in this paper. The PP t-statistic for *logPROD* in its original level form yields a p-value of 0.509, thus, the null hypothesis cannot be rejected at the 5% significance level. This leads us to the conclusion that *logPROD* is non-stationary in its original level form. Subsequently, the PP test was conducted once more for *logPROD* in its first difference form with both trend and intercept, resulting in a p-value of 0.000. This strongly indicates that *logPROD* is stationary in its first difference form. Consequently, the PP test establishes that *logPROD* is integrated of order 1 (I(1)).

In the case of *logPUB* presented in its original level form, the PP t-statistic yields a p-value of 0.851, preventing us from rejecting the null hypothesis at a 5% significance level. This leads to the conclusion that *logPUB* lacks stationarity in its original level form. Subsequently, the PP test was once again conducted for *logPUB* in its first difference form, resulting in a p-value of 0.001 for the PP t-statistic. As a result, we reject the null hypothesis at the 5% level, suggesting that *logPUB* is stationary in its first difference form. Therefore, the PP test concludes that *logPUB* is integrated of order 1 (I(1)).

Finally, for *logPRIV* in its original level form, the PP t-statistic yields a p-value of 0.169, thereby preventing us from rejecting the null hypothesis at the 5% significance level. This leads us to the conclusion that *logPRIV* lacks stationarity in its original level form. Subsequently, the PP test was once again conducted for *logPRIV* in its first difference form, resulting in a p-value of 0.005 for the PP t-statistic. As a result, we reject the null hypothesis at the 5% level, indicating that *logPRIV* is stationary in its first difference form. Therefore, the PP test concludes that *logPRIV* is integrated of order 1 (I(1)).

Based on the robust PP test, it is established that all three variables, namely *logPROD*, *logPUB*, and *logPRIV*, are integrated of order 1 (I(1)).

5.1.5 Zivot-Andrews Single Break Unit Root Test

Conventional unit root tests such as ADF, PP, and KPSS may lack sufficient sensitivity when dealing with data containing structural breaks. Therefore, it is essential to investigate the presence of any structural breaks in the data. This is why the Zivot-Andrews Single Break Unit Root Test is applied to all three variables employed in the model. It is worth noting that the Zivot Andrews test can only detect a single structural break, even if there are multiple breaks within the series. Hence, its effectiveness may be compromised when multiple structural breaks exist in the data. When conducting the Zivot-Andrews test, three models, namely Models A, B, and C, are available for selection. Model C is consistently favored in accordance with Sen (2003). In the Zivot-Andrews test, the p-value is disregarded due to the presence of structural breaks. The null hypothesis is rejected only when the Zivot-Andrews (ZA) t-statistic exceeds the critical value in absolute terms. The choice of lag for the test is made based on the data's characteristics. For annual data, such as the data used in this study, the lags are usually 1-2 lags.

In the case of *logPROD* in its original level form, the Zivot-Andrews (ZA) t-statistic is -4.908, which is lower than the 5% critical value of -5.08 in absolute terms. Consequently, the null hypothesis of non-stationarity cannot be rejected with one lag. This indicates that *logPROD* lacks stationarity in its original level form according to the ZA test. The structural break was found to be in 2002, which was the inflection point of a decade-long (1996-2006) civil war in Nepal. It was also right after the Royal Massacre of Nepal in 2001. The political instability during the early 2000s had several negative implications on GDP per person employed and public and private investment. Conversely, when considering *logPROD* in its first difference form, the ZA t-statistic is -5.642, which surpasses the 5% critical value of -5.08 in absolute terms. This allows us to reject the null hypothesis of non-stationarity with a structural break for one lag. According to the ZA test, *logPROD* is stationary in its first difference form with the identified structural break occurring in 2008.

In the context of *logPUB* in its original level form, the Zivot-Andrews (ZA) t-statistic is -5.233, exceeding the 5% critical value of -5.08 in absolute terms. As a result, we can reject the null hypothesis of non-stationarity with one lag. This signifies that *logPUB* is stationary in its original level form, with a detected structural break in 2001. It's worth noting that this finding contradicts the outcome of the PP test, where *logPUB* was deemed non-stationary in its level form. The presence of the structural break is supported by real events such as the Royal Massacre and the civil war, but the stronger PP test result is given precedence in the analysis. On the other hand, in the case of *logPUB* in its first difference form, the ZA t-statistic stands at -4.665, falling short of the critical value at a 5% significance level. This suggests non-stationarity in the first difference form, although this outcome contradicts the result obtained from the PP test. Therefore, this result is disregarded in favor of the more robust PP test result.

Lastly, with respect to *logPRIV* in its original level form, the Zivot-Andrews (ZA) t-statistic is -4.595, which falls below the 5% critical value of -5.08 in absolute terms. As a result, we cannot reject the null hypothesis of non-stationarity with one lag. This implies that *logPRIV* lacks stationarity in its original level form, as indicated by the ZA test. The identified structural break corresponds to the year 1999, coinciding with Nepal's general election amid the ongoing civil war. Conversely, when considering *logPRIV* in its first difference form, the ZA t-statistic amounts to -5.425, exceeding the 5% critical value of -5.08 in absolute terms. This enables us to reject the null hypothesis of non-stationarity with a structural break with one lag. In the first difference form, the structural break is identified in the year 2000. Therefore, according to the ZA test, *logPRIV* is stationary in its first difference form with a detected structural break.

Hence, following a thorough examination of all the test outcomes, it is determined that all three variables, namely *logPROD*, *logPUB*, and *logPRIV*, are integrated of order one (I(1)).

5.2 Cointegration Analysis

The three variables included in the model, namely *logPROD*, *logPUB*, and *logPRIV*, have all been determined to exhibit the same order of integration, which is I(1). Consequently, cointegration analysis can be conducted to examine the existence of a stable, long-term relationship among these variables. There are two methods for performing cointegration analysis: the Engle-Granger procedure and the Johansen procedure. The Engle-Granger (E-G) procedure only finds one cointegrating relationship and is used only when we have two variables. The Johansen procedure can find multiple cointegration relationships if present and is used when there are more than two variables in the model. Since there are three variables in the model, the Johansen procedure is used in this paper.

5.2.1 Johansen Procedure

Johansen Procedure provides 5 different models to choose from to run a cointegration analysis. Models 1 and 5 are usually excluded considering the unrealistic assumptions underlying them. So, among the remaining 3 models, the best model needs to be found using the Pantula Principle. Table 2 shows the comparative statistics for models 2, 3 and 4 and helps choose the most suitable model.

Model 2 is characterized as the most constrained model, incorporating an intercept in the cointegrating equation but no trend, and omitting both the intercept and trend in the VAR model. Model 3 is a comparatively less constrained model, encompassing an intercept but no trend in both the cointegrating equation and the VAR model. Model 4 represents the least constrained model, featuring an intercept in both the cointegrating equation and the VAR model, as well as a trend exclusively in the cointegrating equation while excluding it from the VAR model.

Johansen cointegration analysis is performed for the trio of variables: *logPROD*, *logPUB*, and *logPRIV*, alongside the incorporation of three dummy variables with a lag of up to 2. Following the Pantula selection procedure, the results indicate the presence of one cointegrating vector at a 5% significance level. Additionally, the procedure advises selecting Model 2, as it stands as the final significant estimate before reaching the point where the null hypothesis of no cointegration cannot be rejected at a 5% significance level. These findings are detailed in Table 2.

5.2.2 Vector Error Correction Model (VECM)

The Johansen procedure identified the presence of a single cointegrating vector, signifying the existence of a stable relationship among the three model variables. Consequently, a VEC model is computed for the three endogenous variables, namely *logPROD*, *logPUB*, and *logPRIV*, and is extended to include the three exogenous dummy variables, D1, D2, and D3, employing a lag length of two. The outcomes are provided in Table 3.

Table 2. Pantula Selection Procedure

r (number of cointegrating vectors)	**n-r (number of variables minus number of cointegrating vectors)**	**Model 2**	**Model 3**	**Model 4**
Up to 0	3	50.788 reject	23.478* fail	49.486 reject
Up to 1	2	17.383 fail	4.795 fail	21.683 fail
Up to 2	1	1.823 fail	1.201 fail	3.067 fail

Model 2: Trace test suggests the presence of 1 cointegrating eqn at the 0.05 level.
Model 3: Trace test suggests the presence of 0 cointegrating eqn at the 0.05 level.
Model 4: Trace test suggests the presence of 1 cointegrating eqn at the 0.05 level.
* represents the last significant estimate before the null of no cointegration cannot be rejected at the 5% level

The outcomes for the variables in the extended term align with the theoretical assumption of having a positive impact of public and private investment on labor productivity. The VECM model shows that a one percent increase in public investment increases labor productivity by 0.04 percent, all else held constant. Also, a one percent increase in private investment increases labor productivity by 0.39 percent in the long run, all else held constant. Private investment and public investment are significant at 5 % and 10% level respectively. Although both private and public investment have a positive impact on labor productivity in Nepal, it is private investment that has a more positive and significant impact according to the VECM.

The VECM finds two negative and highly significant adjustment coefficients for two of the three equations: D(*logPROD*) and D(*logPUB*). This means that there is a short-run adjustment mechanism for these two system equations. Based on the VECM results, it is indicated that the D(*logPUB*) equation is the best one, however, the D(*logPROD*) equation is also very significant. Both equations have correct signs (negative) on the error correction term which means those two systems adjust to their long-run equilibrium values. Both models have low SBC and AIC values. For *logPROD*, 10% deviation away from equilibrium this year is corrected by 2.69% in the next year. In the case of *logPUB*, a 10% deviation from the equilibrium in the current year is rectified by 24.22% in the subsequent year.

In order to examine the weak exogeneity of the variables, zero restrictions were applied to the adjustment coefficients of each equation. Based on the restriction, it is concluded that only *logPRIV* is weakly exogenous and the remaining two variables: *logPROD* and *logPUB* are found to be endogenous. The results are attached in the appendix.

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Table 3. VECM Results

Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 05/09/23 Time: 14:35
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOGPROD(-1)	1.000000
LOGPUB(-1)	-0.038874 (0.02411) [-1.61257]
LOGPRIV(-1)	-0.396765 (0.01942) [-20.4268]
C	1.400035 (0.53415) [2.62104]

Error Correction:	D(LOGPROD)	D(LOGPUB)	D(LOGPRIV)
CointEq1	-0.269524 (0.08832) [-3.05157]	-2.422077 (0.63135) [-3.83634]	0.036509 (0.38996) [0.09362]
D(LOGPROD(-1))	-0.175009 (0.20512) [-0.85321]	-3.583635 (1.46622) [-2.44413]	2.268427 (0.90563) [2.50481]
D(LOGPROD(-2))	-0.075896 (0.20457) [-0.37101]	-2.186644 (1.46229) [-1.49535]	0.983426 (0.90320) [1.08882]
D(LOGPUB(-1))	0.044286 (0.03325) [1.33178]	-0.434886 (0.23770) [-1.82954]	0.071520 (0.14682) [0.48713]
D(LOGPUB(-2))	-0.010459 (0.03272) [-0.31965]	0.252108 (0.23390) [1.07786]	-0.180002 (0.14447) [-1.24595]
D(LOGPRIV(-1))	0.006298 (0.06207) [0.10145]	-1.523245 (0.44372) [-3.43287]	0.039694 (0.27407) [0.14483]
D(LOGPRIV(-2))	-0.076808 (0.07570) [-1.01463]	-0.153521 (0.54113) [-0.28371]	-0.068641 (0.33423) [-0.20537]
D1	-0.011240 (0.01045) [-1.07564]	-0.226062 (0.07469) [-3.02653]	-0.010432 (0.04614) [-0.22613]
D2	-0.028679 (0.01432) [-2.00262]	0.175963 (0.10237) [1.71883]	-0.039531 (0.06323) [-0.62521]
D3	-0.004300 (0.01906) [-0.22556]	-0.075533 (0.13626) [-0.55433]	-0.209542 (0.08416) [-2.48971]

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R-squared	0.516869	0.646182	0.367640
Adj. R-squared	0.275304	0.469272	0.051460
Sum sq. resids	0.005763	0.294480	0.112346
S.E. equation	0.017893	0.127906	0.079003
F-statistic	2.139666	3.652618	1.162756
Log likelihood	79.10832	24.03618	37.52700
Akaike AIC	-4.936308	-1.002584	-1.966214
Schwarz SC	-4.460521	-0.526797	-1.490427
Mean dependent	0.027437	0.040410	0.059674
S.D. dependent	0.021019	0.175572	0.081118

Determinant resid covariance (dof adj.)	1.92E-08
Determinant resid covariance	5.10E-09
Log likelihood	148.1136
Akaike information criterion	-8.150971
Schwarz criterion	-6.533294

Number of coefficients	34

For D(*logPROD*), the VECM indicates that a percentage increase in *logPUB* and *logPRIV* last year would increase labor productivity by 0.04% and 0.006% respectively in the short run. But, the short-run impacts are not significant at the 5 % level which hints that any kind of investment would need some time to impact labor productivity. The result also shows that a one percent increase in *logPROD* last year will decrease labor productivity by 0.18% and it decreases more slowly in the upcoming years. In the case of Nepal, the effect of lag terms of *logPROD* is found to be insignificant. D2 (dummy used for the 2015 earthquake) only has a significant and negative impact on *logPROD* in the short run. Dummy variables D1 and D3 do not have a significant impact on explaining the variation in *logPROD*.

For D(*logPUB*), the VECM indicates that a percentage increase in *logPROD* and *logPRIV* last year would decrease public investment by 3.58% and 1.52% respectively in the short run. The short-run impacts of both *logPROD* and *logPRIV* are significant at the 5% level. This suggests that public and private investment are substitutes in the short run. Public investments generally take time to show its positive impact on labor productivity, so it might be the reason why they are negatively related in the short-run when *logPUB* is taken as an endogenous variable. The effect of last year's public investment on *logPUB* is found to be insignificant in the short run. D1 (dummy for civil war years) is highly significant and has a negative impact on *logPROD* which makes economic sense because public investments (except military spending) will go down drastically in the short run when there is a civil war in a country. Dummy variables D1 and D3 do not play a significant role in explaining the variation in *logPUB*.

For D(*logPRIV*), the VECM indicates that a percentage increase in *logPROD* and *logPUB* last year would increase private investment by 2.26% and 0.07% respectively in the short run. The short-run impact of *logPROD* is significant at 5 % level but that of *logPUB* is insignificant. This suggests that private investors put high emphasis on high labor productivity before making investment decisions. As suggested by theory, it looks like public and private investment can sometimes be complementary and sometimes be substitutes. It appears like public investment positively impacts private investment but private investment negatively impacts public investment in the short run in view of the results of two equations: D(*logPUB*) and D(*logPRIV*). But, deeper analysis needs to be done before making concluding remarks about the relationship of public and private investments. The effect of last year's private investment on *logPRIV* is found to be insignificant but positive in the short run. D3 (dummy for COVID pandemic) is significant and has a negative impact on *logPRIV* which makes economic sense because private investments went down almost everywhere during the pandemic and Nepal was not an exception to that. Dummy variables D1 and D2 do not have a significant impact on explaining the variation in *logPRIV*.

6. Granger Causality/Block Exogeneity Tests

To further investigate the direction of causality, Granger Causality/Block Exogeneity Test is conducted. As cointegration among all three variables has been confirmed through the Johansen procedure, it is now possible to perform the Granger Causality Test. The outcomes of this test are presented in Table 4.

Table 4. Granger Causality Tests

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 05/09/23 Time: 16:13
Sample: 1991 2021
Included observations: 28

Dependent variable: D(LOGPROD)

Excluded	Chi-sq	df	Prob.
D(LOGPUB)	1.893905	2	0.3879
D(LOGPRIV)	1.149547	2	0.5628
All	5.383717	4	0.2501

Dependent variable: D(LOGPUB)

Excluded	Chi-sq	df	Prob.
D(LOGPROD)	7.006054	2	0.0301
D(LOGPRIV)	12.06320	2	0.0024
All	20.98794	4	0.0003

Dependent variable: D(LOGPRIV)

Excluded	Chi-sq	df	Prob.
D(LOGPROD)	6.619769	2	0.0365
D(LOGPUB)	1.815107	2	0.4035
All	6.930848	4	0.1396

The Granger Causality Test indicates that labor productivity "Granger causes" public investment. It shows that private investment also "Granger causes" public investment. In addition, it also shows that labor productivity and private investment jointly "Granger cause" public investment. This result strengthens the VECM result which had shown public investment to be an endogenous variable.

The test also shows that labor productivity "Granger causes" private investment which makes economic sense and supports the literature as private investments are solely focused on optimizing profit opportunities.

The test does not show public and private investment to "Granger cause" labor productivity. This could be attributed to the fact that the test was conducted with only 2 lags, whereas the impact on the variables might become evident after a longer lag period, exceeding 2 lags. Generally, investments are meant to take some time before they impact labor market conditions in an economy. To test for this, a Pairwise Granger Causality Test was run and a causation from *logPUB* to *logPROD* was found at 4 and 5 lags which shows that public investments take time to impact labor productivity. The results are attached in the appendix.

7. Summary and Conclusion

This paper examined the relationship between GDP per person employed (labor productivity), public investment, and private investment in Nepal during the 1991-2021 period with an emphasis on examining the impact of public and private investment on labor productivity by using the Johansen cointegration method and estimating a VECM. The results show that there is cointegration among the three variables meaning that there is a long-run stable equilibrium relationship among labor productivity, public investment, and private investment. In the long run, it is found that both public and private investment have a positive impact on labor productivity. Private investment is found to have a stronger and more significant impact compared to public investment in the long run. Labor productivity was expected to be endogenous and is found to be one as well. Public investment was expected to be exogenous but is found to be endogenous which is one of the major takeaways of the paper. In the case of Nepal, public investment is endogenous meaning that it is much more than just a legislative decision, rather it is determined by the economic activity happening in the Nepalese economy. On the causality side, it is found that both labor productivity and private investment "cause" public investment after 2 lags. It is also found that labor productivity "causes" private investment after 2 lags. However, it is confirmed that public investment takes time to "cause" labor productivity as there was a causation from public investment to labor productivity only at lags 4 and 5. Based on these results, it can be said that the Nepalese government needs to make private investment friendly policies to generate more private investment which would then improve labor productivity which would again "cause" private and public investment and create a "virtuous circle of labor productivity and economic growth" in Nepal.

Some of the limitations of this study are the high level of aggregation of the data utilized and the paucity of data for the variables in question. As more data becomes available, future studies might want to assess the impact of public and private investment spending on labor productivity in different sectors of the Nepalese economy, such as the industrial, primary, and service sectors. This might be undertaken via a panel unit root and cointegration approach. Second, other relevant variables might be included, again, based on availability, such as the labor force, and disaggregated expenditures on physical infrastructure, education, and health.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

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The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix

ADF Test results for logPROD:

a)Level form:

Augmented Dickey-Fuller Unit Root Test on LOGPROD

Null Hypothesis: LOGPROD has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.143718	0.5019
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGPROD)
Method: Least Squares
Date: 05/07/23 Time: 15:34
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPROD(-1)	-0.261720	0.122087	-2.143718	0.0412
C	2.120746	0.980029	2.163962	0.0395
@TREND("1991")	0.007412	0.003293	2.250663	0.0328

R-squared	0.170961	Mean dependent var	0.026226
Adjusted R-squared	0.109551	S.D. dependent var	0.020798
S.E. of regression	0.019626	Akaike info criterion	-4.929278
Sum squared resid	0.010400	Schwarz criterion	-4.789159
Log likelihood	76.93918	Hannan-Quinn criter.	-4.884453
F-statistic	2.783916	Durbin-Watson stat	1.942349
Prob(F-statistic)	0.079572		

b) First Difference Form:

Augmented Dickey-Fuller Unit Root Test on D(LOGPROD)

Null Hypothesis: D(LOGPROD) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.109141	0.0016
Test critical values:	1% level	-4.323979	
	5% level	-3.580622	
	10% level	-3.225334	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGPROD,2)
Method: Least Squares
Date: 05/07/23 Time: 15:43
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGPROD(-1))	-1.701868	0.333103	-5.109141	0.0000
D(LOGPROD(-1),2)	0.398506	0.214526	1.857613	0.0755
C	0.034656	0.010193	3.400144	0.0024
@TREND("1991")	0.000743	0.000536	1.387208	0.1781

R-squared	0.613757	Mean dependent var	-0.000942
Adjusted R-squared	0.565477	S.D. dependent var	0.030880
S.E. of regression	0.020356	Akaike info criterion	-4.819337
Sum squared resid	0.009945	Schwarz criterion	-4.629022
Log likelihood	71.47071	Hannan-Quinn criter.	-4.761156
F-statistic	12.71237	Durbin-Watson stat	1.788515
Prob(F-statistic)	0.000036		

ADF Test results for logPUB:

a) Level form

Augmented Dickey-Fuller Unit Root Test on LOGPUB

Null Hypothesis: LOGPUB has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.178101	0.8971
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGPUB)
Method: Least Squares
Date: 05/07/23 Time: 16:09
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPUB(-1)	-0.110257	0.093589	-1.178101	0.2490
C	2.334531	1.998396	1.168203	0.2529
@TREND("1991")	0.007174	0.004611	1.555754	0.1314

R-squared	0.084053	Mean dependent var	0.038786
Adjusted R-squared	0.016205	S.D. dependent var	0.169552
S.E. of regression	0.168172	Akaike info criterion	-0.633017
Sum squared resid	0.763611	Schwarz criterion	-0.492898
Log likelihood	12.49526	Hannan-Quinn criter.	-0.588192
F-statistic	1.238837	Durbin-Watson stat	1.430190
Prob(F-statistic)	0.305670		

b) First Difference form

Augmented Dickey-Fuller Unit Root Test on D(LOGPUB)

Null Hypothesis: D(LOGPUB) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.774215	0.0005
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGPUB,2)
Method: Least Squares
Date: 05/07/23 Time: 16:14
Sample (adjusted): 1993 2021
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGPUB(-1))	-0.701185	0.185783	-3.774215	0.0008

R-squared	0.336353	Mean dependent var	0.007285
Adjusted R-squared	0.336353	S.D. dependent var	0.208069
S.E. of regression	0.169503	Akaike info criterion	-0.678023
Sum squared resid	0.804471	Schwarz criterion	-0.630875
Log likelihood	10.83134	Hannan-Quinn criter.	-0.663257
Durbin-Watson stat	1.947156		

ADF Test results for logPRIV:

a) Level form

Augmented Dickey-Fuller Unit Root Test on LOGPRIV

Null Hypothesis: LOGPRIV has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.504152	0.0577
Test critical values:	1% level	-4.309824	
	5% level	-3.574244	
	10% level	-3.221728	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGPRIV)
Method: Least Squares
Date: 05/07/23 Time: 16:34
Sample (adjusted): 1993 2021
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPRIV(-1)	-0.601785	0.171735	-3.504152	0.0017
D(LOGPRIV(-1))	0.401094	0.184114	2.178511	0.0390
C	13.31937	3.781522	3.522225	0.0017
@TREND("1991")	0.039209	0.011519	3.403889	0.0022

R-squared	0.342414	Mean dependent var	0.064344
Adjusted R-squared	0.263504	S.D. dependent var	0.083532
S.E. of regression	0.071686	Akaike info criterion	-2.305590
Sum squared resid	0.128473	Schwarz criterion	-2.116997
Log likelihood	37.43105	Hannan-Quinn criter.	-2.246525
F-statistic	4.339287	Durbin-Watson stat	1.988574
Prob(F-statistic)	0.013598		

b) First Difference Form

Augmented Dickey-Fuller Unit Root Test on D(LOGPRIV)

Null Hypothesis: D(LOGPRIV) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=7)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.481161	0.0070
Test critical values:	1% level	-4.323979	
	5% level	-3.580622	
	10% level	-3.225334	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGPRIV,2)
Method: Least Squares
Date: 05/07/23 Time: 16:39
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGPRIV(-1))	-1.260034	0.281185	-4.481161	0.0002
D(LOGPRIV(-1),2)	0.345584	0.213168	1.621181	0.1180
C	0.072876	0.039565	1.841915	0.0779
@TREND("1991")	0.000459	0.001916	0.239344	0.8129

R-squared	0.525787	Mean dependent var	-0.007871
Adjusted R-squared	0.466510	S.D. dependent var	0.111460
S.E. of regression	0.081411	Akaike info criterion	-2.047049
Sum squared resid	0.159066	Schwarz criterion	-1.856734
Log likelihood	32.65869	Hannan-Quinn criter.	-1.988868
F-statistic	8.870049	Durbin-Watson stat	2.043480
Prob(F-statistic)	0.000391		

KPSS test for logPROD:

a)Level form

KPSS Unit Root Test on LOGPROD

Null Hypothesis: LOGPROD is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.181672
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000848
HAC corrected variance (Bartlett kernel)	0.002713

KPSS Test Equation
Dependent Variable: LOGPROD
Method: Least Squares
Date: 05/07/23 Time: 15:55
Sample: 1991 2021
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.052535	0.010556	762.8074	0.0000
@TREND("1991")	0.026896	0.000604	44.49665	0.0000

R-squared	0.985565	Mean dependent var	8.455982
Adjusted R-squared	0.985067	S.D. dependent var	0.246330
S.E. of regression	0.030102	Akaike info criterion	-4.106117
Sum squared resid	0.026278	Schwarz criterion	-4.013602
Log likelihood	65.64482	Hannan-Quinn criter.	-4.075959
F-statistic	1979.952	Durbin-Watson stat	0.477898
Prob(F-statistic)	0.000000		

b) First Difference form

KPSS Unit Root Test on D(LOGPROD)

Null Hypothesis: D(LOGPROD) is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.249660
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000418
HAC corrected variance (Bartlett kernel)	0.000243

KPSS Test Equation
Dependent Variable: D(LOGPROD)
Method: Least Squares
Date: 05/07/23 Time: 16:02
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.026226	0.003797	6.906699	0.0000

R-squared	0.000000	Mean dependent var	0.026226
Adjusted R-squared	0.000000	S.D. dependent var	0.020798
S.E. of regression	0.020798	Akaike info criterion	-4.875124
Sum squared resid	0.012545	Schwarz criterion	-4.828417
Log likelihood	74.12685	Hannan-Quinn criter.	-4.860182
Durbin-Watson stat	2.054437		

KPSS test for logPUB:

a)Level form

KPSS Unit Root Test on LOGPUB

Null Hypothesis: LOGPUB is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.152160
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.108478
HAC corrected variance (Bartlett kernel)	0.390344

KPSS Test Equation
Dependent Variable: LOGPUB
Method: Least Squares
Date: 05/07/23 Time: 16:21
Sample: 1991 2021
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	21.35099	0.119420	178.7888	0.0000
@TREND("1991")	0.033841	0.006838	4.948967	0.0000

R-squared	0.457866	Mean dependent var	21.85860
Adjusted R-squared	0.439171	S.D. dependent var	0.454714
S.E. of regression	0.340529	Akaike info criterion	0.745705
Sum squared resid	3.362831	Schwarz criterion	0.838221
Log likelihood	-9.558434	Hannan-Quinn criter.	0.775863
F-statistic	24.49228	Durbin-Watson stat	0.248130
Prob(F-statistic)	0.000029		

b) First Difference form

KPSS Unit Root Test on D(LOGPUB)

Null Hypothesis: D(LOGPUB) is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.069578
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.026762
HAC corrected variance (Bartlett kernel)	0.033057

KPSS Test Equation
Dependent Variable: D(LOGPUB)
Method: Least Squares
Date: 05/07/23 Time: 16:23
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.018612	0.063411	-0.293516	0.7713
@TREND("1991")	0.003703	0.003572	1.036755	0.3087

R-squared	0.036969	Mean dependent var	0.038786
Adjusted R-squared	0.002575	S.D. dependent var	0.169552
S.E. of regression	0.169333	Akaike info criterion	-0.649557
Sum squared resid	0.802864	Schwarz criterion	-0.556144
Log likelihood	11.74336	Hannan-Quinn criter.	-0.619673
F-statistic	1.074860	Durbin-Watson stat	1.510306
Prob(F-statistic)	0.308721		

KPSS test for logPRIV:

a)Level form

KPSS Unit Root Test on LOGPRIV

Null Hypothesis: LOGPRIV is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.107237
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.007511
HAC corrected variance (Bartlett kernel)	0.011587

KPSS Test Equation
Dependent Variable: LOGPRIV
Method: Least Squares
Date: 05/07/23 Time: 16:45
Sample: 1991 2021
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	22.11644	0.031424	703.8109	0.0000
@TREND("1991")	0.066188	0.001799	36.78512	0.0000

R-squared	0.979018	Mean dependent var	23.10926
Adjusted R-squared	0.978295	S.D. dependent var	0.608207
S.E. of regression	0.089606	Akaike info criterion	-1.924457
Sum squared resid	0.232846	Schwarz criterion	-1.831942
Log likelihood	31.82909	Hannan-Quinn criter.	-1.894300
F-statistic	1353.145	Durbin-Watson stat	0.854837
Prob(F-statistic)	0.000000		

b) First Difference form

KPSS Unit Root Test on D(LOGPRIV)

Null Hypothesis: D(LOGPRIV) is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.149218
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.006635
HAC corrected variance (Bartlett kernel)	0.003340

KPSS Test Equation
Dependent Variable: D(LOGPRIV)
Method: Least Squares
Date: 05/07/23 Time: 16:52
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.066398	0.015126	4.389785	0.0001

R-squared	0.000000	Mean dependent var	0.066398
Adjusted R-squared	0.000000	S.D. dependent var	0.082847
S.E. of regression	0.082847	Akaike info criterion	-2.110884
Sum squared resid	0.199044	Schwarz criterion	-2.064177
Log likelihood	32.66326	Hannan-Quinn criter.	-2.095942
Durbin-Watson stat	1.717937		

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PP test for logPROD:

a)Level form

Phillips-Perron Unit Root Test on LOGPROD

Null Hypothesis: LOGPROD has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.130139	0.5091
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000347
HAC corrected variance (Bartlett kernel)	0.000340

Phillips-Perron Test Equation
Dependent Variable: D(LOGPROD)
Method: Least Squares
Date: 05/07/23 Time: 15:45
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPROD(-1)	-0.261720	0.122087	-2.143718	0.0412
C	2.120746	0.980029	2.163962	0.0395
@TREND("1991")	0.007412	0.003293	2.250663	0.0328

R-squared	0.170961	Mean dependent var	0.026226
Adjusted R-squared	0.109551	S.D. dependent var	0.020798
S.E. of regression	0.019626	Akaike info criterion	-4.929278
Sum squared resid	0.010400	Schwarz criterion	-4.789159
Log likelihood	76.93918	Hannan-Quinn criter.	-4.884453
F-statistic	2.783916	Durbin-Watson stat	1.942349
Prob(F-statistic)	0.079572		

b) First Difference form

Phillips-Perron Unit Root Test on D(LOGPROD)

Null Hypothesis: D(LOGPROD) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 28 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.558096	0.0000
Test critical values:	1% level	-4.309824	
	5% level	-3.574244	
	10% level	-3.221728	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000401
HAC corrected variance (Bartlett kernel)	3.45E-05

Phillips-Perron Test Equation
Dependent Variable: D(LOGPROD,2)
Method: Least Squares
Date: 05/07/23 Time: 15:49
Sample (adjusted): 1993 2021
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGPROD(-1))	-1.209168	0.218214	-5.541197	0.0000
C	0.024791	0.009111	2.720868	0.0115
@TREND("1991")	0.000489	0.000499	0.979926	0.3362

R-squared	0.548660	Mean dependent var	-0.000913
Adjusted R-squared	0.513941	S.D. dependent var	0.030324
S.E. of regression	0.021141	Akaike info criterion	-4.777462
Sum squared resid	0.011621	Schwarz criterion	-4.636017
Log likelihood	72.27320	Hannan-Quinn criter.	-4.733163
F-statistic	15.80309	Durbin-Watson stat	1.941210
Prob(F-statistic)	0.000032		

PP test for logPUB:

a)Level form

Phillips-Perron Unit Root Test on LOGPUB

Null Hypothesis: LOGPUB has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.364512	0.8508
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.025454
HAC corrected variance (Bartlett kernel)	0.032328

Phillips-Perron Test Equation
Dependent Variable: D(LOGPUB)
Method: Least Squares
Date: 05/07/23 Time: 16:18
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPUB(-1)	-0.110257	0.093589	-1.178101	0.2490
C	2.334531	1.998396	1.168203	0.2529
@TREND("1991")	0.007174	0.004611	1.555754	0.1314

R-squared	0.084053	Mean dependent var	0.038786
Adjusted R-squared	0.016205	S.D. dependent var	0.169552
S.E. of regression	0.168172	Akaike info criterion	-0.633017
Sum squared resid	0.763611	Schwarz criterion	-0.492898
Log likelihood	12.49526	Hannan-Quinn criter.	-0.588192
F-statistic	1.238837	Durbin-Watson stat	1.430190
Prob(F-statistic)	0.305670		

b) First Difference form

Phillips-Perron Unit Root Test on D(LOGPUB)

Null Hypothesis: D(LOGPUB) has a unit root
Exogenous: None
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.765421	0.0005
Test critical values:	1% level	-2.647120	
	5% level	-1.952910	
	10% level	-1.610011	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.027740
HAC corrected variance (Bartlett kernel)	0.027419

Phillips-Perron Test Equation
Dependent Variable: D(LOGPUB,2)
Method: Least Squares
Date: 05/07/23 Time: 16:20
Sample (adjusted): 1993 2021
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGPUB(-1))	-0.701185	0.185783	-3.774215	0.0008

R-squared	0.336353	Mean dependent var	0.007285
Adjusted R-squared	0.336353	S.D. dependent var	0.208069
S.E. of regression	0.169503	Akaike info criterion	-0.678023
Sum squared resid	0.804471	Schwarz criterion	-0.630875
Log likelihood	10.83134	Hannan-Quinn criter.	-0.663257
Durbin-Watson stat	1.947156		

PP test for logPRIV:

a)Level form

Phillips-Perron Unit Root Test on LOGPRIV

Null Hypothesis: LOGPRIV has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.925597	0.1691
Test critical values:	1% level	-4.296729	
	5% level	-3.568379	
	10% level	-3.218382	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.005098
HAC corrected variance (Bartlett kernel)	0.006083

Phillips-Perron Test Equation
Dependent Variable: D(LOGPRIV)
Method: Least Squares
Date: 05/07/23 Time: 16:40
Sample (adjusted): 1992 2021
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPRIV(-1)	-0.437398	0.158484	-2.759892	0.0103
C	9.726389	3.493786	2.783911	0.0097
@TREND("1991")	0.028042	0.010696	2.621769	0.0142

R-squared	0.231692	Mean dependent var	0.066398
Adjusted R-squared	0.174780	S.D. dependent var	0.082847
S.E. of regression	0.075259	Akaike info criterion	-2.241115
Sum squared resid	0.152927	Schwarz criterion	-2.100995
Log likelihood	36.61673	Hannan-Quinn criter.	-2.196290
F-statistic	4.071079	Durbin-Watson stat	1.509097
Prob(F-statistic)	0.028492		

b) First Difference form

Phillips-Perron Unit Root Test on D(LOGPRIV)

Null Hypothesis: D(LOGPRIV) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.609229	0.0050
Test critical values:	1% level	-4.309824	
	5% level	-3.574244	
	10% level	-3.221728	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.006606
HAC corrected variance (Bartlett kernel)	0.002415

Phillips-Perron Test Equation
Dependent Variable: D(LOGPRIV,2)
Method: Least Squares
Date: 05/07/23 Time: 16:42
Sample (adjusted): 1993 2021
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGPRIV(-1))	-0.887815	0.197121	-4.503909	0.0001
C	0.068805	0.037768	1.821791	0.0800
@TREND("1991")	-0.000767	0.001909	-0.401575	0.6913

R-squared	0.438453	Mean dependent var	-0.005216
Adjusted R-squared	0.395258	S.D. dependent var	0.110382
S.E. of regression	0.085839	Akaike info criterion	-1.974999
Sum squared resid	0.191575	Schwarz criterion	-1.833554
Log likelihood	31.63748	Hannan-Quinn criter.	-1.930700
F-statistic	10.15035	Durbin-Watson stat	1.917288
Prob(F-statistic)	0.000552		

Zivot-Andrews (ZA) test for logPROD:

a)Level form

Zivot-Andrews Unit Root Test
Date: 05/07/23 Time: 16:05
Sample: 1991 2021
Included observations: 31
Null Hypothesis: LOGPROD has a unit root with a structural break in both the intercept and trend
Chosen lag length: 0 (maximum lags: 1)
Chosen break point: 2002

	t-Statistic	Prob. *
Zivot-Andrews test statistic	-4.907712	0.007757
1% critical value:	-5.57	
5% critical value:	-5.08	
10% critical value:	-4.82	

* Probability values are calculated from a standard t-distribution and do not take into account the breakpoint selection process

b) First Difference form

Zivot-Andrews Unit Root Test
Date: 05/07/23 Time: 16:05
Sample: 1991 2021
Included observations: 31
Null Hypothesis: LOGPROD_FD has a unit root with a structural break in both the intercept and trend
Chosen lag length: 1 (maximum lags: 1)
Chosen break point: 2008

	t-Statistic	Prob. *
Zivot-Andrews test statistic	-5.642243	0.080679
1% critical value:	-5.57	
5% critical value:	-5.08	
10% critical value:	-4.82	

* Probability values are calculated from a standard t-distribution and do not take into account the breakpoint selection process

Zivot-Andrews (ZA) test for logPUB:

a)Level form

Zivot-Andrews Unit Root Test
Date: 05/07/23 Time: 16:05
Sample: 1991 2021
Included observations: 31
Null Hypothesis: LOGPUB has a unit root with a structural break in both the intercept and trend
Chosen lag length: 1 (maximum lags: 1)
Chosen break point: 2001

	t-Statistic	Prob. *
Zivot-Andrews test statistic	-5.233143	0.002402
1% critical value:	-5.57	
5% critical value:	-5.08	
10% critical value:	-4.82	

* Probability values are calculated from a standard t-distribution and do not take into account the breakpoint selection process

b) First Difference form

Zivot-Andrews Unit Root Test
Date: 05/07/23 Time: 16:05
Sample: 1991 2021
Included observations: 31
Null Hypothesis: LOGPUB_FD has a unit root with a structural break in both the intercept and trend
Chosen lag length: 0 (maximum lags: 1)
Chosen break point: 2004

	t-Statistic	Prob. *
Zivot-Andrews test statistic	-4.665359	0.046104
1% critical value:	-5.57	
5% critical value:	-5.08	
10% critical value:	-4.82	

* Probability values are calculated from a standard t-distribution and do not take into account the breakpoint selection process

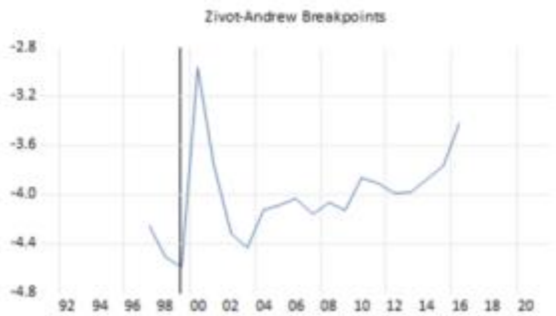
Zivot-Andrews (ZA) test for logPRIV:

a)Level form

Zivot-Andrews Unit Root Test
Date: 05/07/23 Time: 16:05
Sample: 1991 2021
Included observations: 31
Null Hypothesis: LOGPRIV has a unit root with a structural break in both the intercept and trend
Chosen lag length: 1 (maximum lags: 1)
Chosen break point: 1999

	t-Statistic	Prob. *
Zivot-Andrews test statistic	-4.595176	0.200417
1% critical value:	-5.57	
5% critical value:	-5.08	
10% critical value:	-4.82	

* Probability values are calculated from a standard t-distribution and do not take into account the breakpoint selection process



b) First Difference form

Zivot-Andrews Unit Root Test
Date: 05/07/23 Time: 16:05
Sample: 1991 2021
Included observations: 31
Null Hypothesis: LOGPRIV_FD has a unit root with a structural break in both the intercept and trend
Chosen lag length: 1 (maximum lags: 1)
Chosen break point: 2000

	t-Statistic	Prob. *
Zivot-Andrews test statistic	-5.424956	0.006046
1% critical value:	-5.57	
5% critical value:	-5.08	
10% critical value:	-4.82	

* Probability values are calculated from a standard t-distribution and do not take into account the breakpoint selection process

Johansen Test with Model 2:

Johansen Cointegration Test

Date: 05/09/23 Time: 14:10
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: LOGPROD LOGPUB LOGPRIV
Exogenous series: D1 D2 D3
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.696696	50.78774	35.19275	0.0005
At most 1	0.426340	17.38322	20.26184	0.1188
At most 2	0.063036	1.823078	9.164546	0.8126

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Johansen Test with Model 3:

Johansen Cointegration Test

Date: 05/09/23 Time: 14:12
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Trend assumption: Linear deterministic trend
Series: LOGPROD LOGPUB LOGPRIV
Exogenous series: D1 D2 D3
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.486882	23.47817	29.79707	0.2234
At most 1	0.120460	4.795197	15.49471	0.8302
At most 2	0.041994	1.201237	3.841465	0.2731

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Johansen Test with Model 4:

Johansen Cointegration Test

Date: 05/09/23 Time: 14:13
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LOGPROD LOGPUB LOGPRIV
Exogenous series: D1 D2 D3
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.629524	49.48626	42.91525	0.0097
At most 1	0.485658	21.68317	25.87211	0.1522
At most 2	0.103746	3.066872	12.51798	0.8685

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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Weak Exogeneity Test for logPROD [A(1,1) = 0] in VECM:

Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 05/10/23 Time: 01:33
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
A(1,1) = 0
Convergence achieved after 16 iterations.
Not all cointegrating vectors are identified
LR test for binding restrictions (rank = 1):
Chi-square(1) 8.501448
Probability 0.003549

Cointegrating Eq:	CointEq1
LOGPROD(-1)	35.78152
LOGPUB(-1)	-0.813060
LOGPRIV(-1)	-13.88876
C	32.81176

Error Correction:	D(LOGPROD)	D(LOGPUB)	D(LOGPRIV)
CointEq1	0.000000	-0.121430	0.032600
	(0.00000)	(0.02297)	(0.01324)
	[NA]	[-5.28674]	[2.46222]
D(LOGPROD(-1))	0.011066	-2.085188	2.315698
	(0.21523)	(1.26437)	(0.82394)
	[0.05141]	[-1.64920]	[2.81051]
D(LOGPROD(-2))	0.071379	-1.118298	1.069925
	(0.21836)	(1.28276)	(0.83593)
	[0.32688]	[-0.87179]	[1.27993]
D(LOGPUB(-1))	0.062891	-0.482222	0.158504
	(0.03708)	(0.21784)	(0.14196)
	[1.69598]	[-2.21367]	[1.11656]
D(LOGPUB(-2))	-0.007495	0.202965	-0.148784
	(0.03687)	(0.21658)	(0.14114)
	[-0.20328]	[0.93715]	[-1.05420]
D(LOGPRIV(-1))	0.019897	-1.847342	0.224057
	(0.07486)	(0.43974)	(0.28656)
	[0.26580]	[-4.20101]	[0.78188]
D(LOGPRIV(-2))	-0.042565	-0.420321	0.166420
	(0.08831)	(0.51876)	(0.33806)
	[-0.48200]	[-0.81024]	[0.49228]
D1	-0.005475	-0.248820	0.019894
	(0.01182)	(0.06944)	(0.04525)
	[-0.46315]	[-3.58311]	[0.43962]
D2	-0.028088	0.201449	-0.048033
	(0.01611)	(0.09466)	(0.06169)
	[-1.74304]	[2.12807]	[-0.77864]
D3	0.000275	-0.046891	-0.204959
	(0.02120)	(0.12456)	(0.08117)
	[0.01298]	[-0.37645]	[-2.52501]

R-squared	0.396322	0.700931	0.405019
Adj. R-squared	0.092982	0.551396	0.107529
Sum sq. resids	0.007213	0.248913	0.105705
S.E. equation	0.020018	0.117585	0.078632
F-statistic	1.307543	4.687414	1.361454
Log likelihood	75.96659	26.38970	38.38002
Akaike AIC	-4.711899	-1.170693	-2.027144
Schwarz SC	-4.236112	-0.694906	-1.551357
Mean dependent	0.027437	0.040410	0.059674
S.D. dependent	0.021019	0.175572	0.081118

Determinant resid covariance (dof adj.)	2.15E-08
Determinant resid covariance	5.70E-09
Log likelihood	143.8629

Vector Error Correction Estimates

Akaike information criterion	-7.847348
Schwarz criterion	-6.229671
Number of coefficients	34

Weak Exogeneity Test for logPUB [A(2,1) = 0] in VECM:

Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 05/10/23 Time: 01:35
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
A(2,1) = 0
Convergence achieved after 30 iterations.
Not all cointegrating vectors are identified
LR test for binding restrictions (rank = 1):
Chi-square(1) 11.55710
Probability 0.000675

Cointegrating Eq:	CointEq1
LOGPROD(-1)	2.286660
LOGPUB(-1)	-0.808782
LOGPRIV(-1)	-1.343944
C	25.64831

Error Correction:	D(LOGPROD)	D(LOGPUB)	D(LOGPRIV)
CointEq1	-0.015038	0.000000	-0.038180
	(0.00329)	(0.00000)	(0.01332)
	[-4.57567]	[NA]	[-2.86710]
D(LOGPROD(-1))	-0.434699	-4.012671	1.499064
	(0.21227)	(2.03579)	(0.99304)
	[-2.04883]	[-1.97107]	[1.50957]
D(LOGPROD(-2))	-0.261081	-2.323764	0.364065
	(0.20066)	(1.92446)	(0.93874)
	[-1.30112]	[-1.20749]	[0.38782]
D(LOGPUB(-1))	0.051097	-0.146468	-0.025292
	(0.02745)	(0.26326)	(0.12842)
	[1.86149]	[-0.55636]	[-0.19695]
D(LOGPUB(-2))	-0.001626	0.372149	-0.198358
	(0.02913)	(0.27938)	(0.13628)
	[-0.05582]	[1.33208]	[-1.45555]
D(LOGPRIV(-1))	0.057716	-0.834594	-0.062693
	(0.04816)	(0.46193)	(0.22533)
	[1.19831]	[-1.80675]	[-0.27912]
D(LOGPRIV(-2))	-0.036579	0.668199	-0.268303
	(0.05831)	(0.55925)	(0.27280)
	[-0.62730]	[1.19480]	[-0.98351]
D1	-0.008009	-0.124242	-0.041590
	(0.00836)	(0.08020)	(0.03912)
	[-0.95777]	[-1.54909]	[-1.06307]
D2	-0.032814	0.140446	-0.039668
	(0.01289)	(0.12363)	(0.06031)
	[-2.54556]	[1.13601]	[-0.65777]
D3	-0.008483	-0.068057	-0.227997
	(0.01733)	(0.16622)	(0.08108)
	[-0.48946]	[-0.40943]	[-2.81191]

R-squared	0.605720	0.480211	0.420597
Adj. R-squared	0.408580	0.220316	0.130896
Sum sq. resids	0.004703	0.432617	0.102938
S.E. equation	0.016165	0.155030	0.075622
F-statistic	3.072535	1.847714	1.451829
Log likelihood	81.95348	18.65123	38.75145
Akaike AIC	-5.139534	-0.617945	-2.053675
Schwarz SC	-4.663747	-0.142157	-1.577887
Mean dependent	0.027437	0.040410	0.059674
S.D. dependent	0.021019	0.175572	0.081118

Determinant resid covariance (dof adj.)	2.35E-08
Determinant resid covariance	6.23E-09
Log likelihood	142.3350

Vector Error Correction Estimates

Akaike information criterion	-7.738217
Schwarz criterion	-6.120541
Number of coefficients	34

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Weak Exogeneity Test for logPRIV [A(3,1) = 0] in VECM:

Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 05/10/23 Time: 01:35
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
A(3,1) = 0
Convergence achieved after 7 iterations.
Not all cointegrating vectors are identified
LR test for binding restrictions (rank = 1):

Chi-square(1)	0.009400
Probability	0.922764

Cointegrating Eq:	CointEq1
LOGPROD(-1)	25.59911
LOGPUB(-1)	-1.006195
LOGPRIV(-1)	-10.17036
C	36.30260

Error Correction:	D(LOGPROD)	D(LOGPUB)	D(LOGPRIV)
CointEq1	-0.010482	-0.091625	0.000000
	(0.00300)	(0.02175)	(0.00000)
	[-3.49525]	[-4.21197]	[NA]
D(LOGPROD(-1))	-0.181757	-3.622441	2.259576
	(0.20510)	(1.47618)	(0.90854)
	[-0.88619]	[-2.45393]	[2.48705]
D(LOGPROD(-2))	-0.080796	-2.211056	0.975313
	(0.20431)	(1.47049)	(0.90504)
	[-0.39546]	[-1.50361]	[1.07765]
D(LOGPUB(-1))	0.044172	-0.429786	0.068796
	(0.03309)	(0.23817)	(0.14659)
	[1.33488]	[-1.80453]	[0.46932]
D(LOGPUB(-2))	-0.010266	0.255644	-0.180833
	(0.03260)	(0.23463)	(0.14440)
	[-0.31493]	[1.08959]	[-1.25228]
D(LOGPRIV(-1))	0.006845	-1.508047	0.035021
	(0.06165)	(0.44375)	(0.27311)
	[0.11102]	[-3.39844]	[0.12823]
D(LOGPRIV(-2))	-0.076754	-0.138144	-0.075308
	(0.07524)	(0.54153)	(0.33329)
	[-1.02013]	[-0.25510]	[-0.22595]
D1	-0.011277	-0.224339	-0.011350
	(0.01040)	(0.07482)	(0.04605)
	[-1.08484]	[-2.99838]	[-0.24647]
D2	-0.028744	0.175025	-0.039367
	(0.01427)	(0.10273)	(0.06323)
	[-2.01384]	[1.70375]	[-0.62264]
D3	-0.004348	-0.075271	-0.209845
	(0.01900)	(0.13677)	(0.08417)
	[-0.22879]	[-0.55036]	[-2.49297]

R-squared	0.519923	0.643560	0.367479
Adj. R-squared	0.279884	0.465340	0.051219
Sum sq. resids	0.005727	0.296663	0.112375
S.E. equation	0.017837	0.128379	0.079013
F-statistic	2.165997	3.611040	1.161950
Log likelihood	79.19709	23.93282	37.52343
Akaike AIC	-4.942649	-0.995202	-1.965959
Schwarz SC	-4.466862	-0.519414	-1.490172
Mean dependent	0.027437	0.040410	0.059674
S.D. dependent	0.021019	0.175572	0.081118

Determinant resid covariance (dof adj.)	1.92E-08
Determinant resid covariance	5.10E-09
Log likelihood	148.1089

Vector Error Correction Estimates

Akaike information criterion	-8.150635
Schwarz criterion	-6.532959
Number of coefficients	34

Granger Causality/Block Exogeneity Test (with lag 2):

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 05/09/23 Time: 16:13
Sample: 1991 2021
Included observations: 28

Dependent variable: D(LOGPROD)

Excluded	Chi-sq	df	Prob.
D(LOGPUB)	1.893905	2	0.3879
D(LOGPRIV)	1.149547	2	0.5628
All	5.383717	4	0.2501

Dependent variable: D(LOGPUB)

Excluded	Chi-sq	df	Prob.
D(LOGPROD)	7.006054	2	0.0301
D(LOGPRIV)	12.06320	2	0.0024
All	20.98794	4	0.0003

Dependent variable: D(LOGPRIV)

Excluded	Chi-sq	df	Prob.
D(LOGPROD)	6.619769	2	0.0365
D(LOGPUB)	1.815107	2	0.4035
All	6.930848	4	0.1396

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Pairwise Granger Causality Tests:

a) With lag 4

Pairwise Granger Causality Tests
Date: 05/09/23 Time: 16:51
Sample: 1991 2021
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGPUB does not Granger Cause LOGPROD	27	3.31201	0.0336
LOGPROD does not Granger Cause LOGPUB		1.96296	0.1436
LOGPRIV does not Granger Cause LOGPROD	27	0.58067	0.6805
LOGPROD does not Granger Cause LOGPRIV		2.97654	0.0475
LOGPRIV does not Granger Cause LOGPUB	27	3.51702	0.0274
LOGPUB does not Granger Cause LOGPRIV		0.82024	0.5290

b) With lag 5

Pairwise Granger Causality Tests
Date: 05/09/23 Time: 16:51
Sample: 1991 2021
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGPUB does not Granger Cause LOGPROD	26	3.60122	0.0244
LOGPROD does not Granger Cause LOGPUB		3.76143	0.0209
LOGPRIV does not Granger Cause LOGPROD	26	0.24954	0.9336
LOGPROD does not Granger Cause LOGPRIV		1.75329	0.1833
LOGPRIV does not Granger Cause LOGPUB	26	2.76772	0.0577
LOGPUB does not Granger Cause LOGPRIV		0.58889	0.7087