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Unemployment and Labour Force Participation in South Korea: Johansen–Type Cointegration Analysis with a Fourier Approach

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Abstract

This study examines the long-run relationship between the unemployment rate and labour force participation rate in South Korea from June 1999 to January 2023. The study utilizes the traditional Johansen cointegration test and augments it with Fourier terms to control for an unknown number of breaks in the cointegration system. The empirical findings suggest a significant long-run relationship between the unemployment rate and labour force participation rate in South Korea, which provides evidence against the unemployment invariance hypothesis. The study also finds evidence of the discouraged-worker effect for males and the added-worker effect for females. The findings of this study have important implications for policymakers in creating more effective plans to lower unemployment and foster economic growth in South Korea. This study contributes to the literature by clarifying the validity of the unemployment invariance hypothesis in the South Korean economy, which is regarded as a growth miracle in the literature. Instead of using the standard configuration of dummy variables, the Johansen cointegration technique now has the ability to adjust for an unknown number of multiple structural breaks in the cointegration system.

Keywords: Unemployment rate, labour force participation rate, unemployment invariance hypothesis, cointegration, Fourier approximation, structural breaks, Korean labour market

JEL Classification: E24, J64, O53

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1. Introduction

The movement of workers is a key factor in analysing the labour market. Worker status changes, such as those from employed to unemployed to "not in the labour force", have a direct impact on corresponding labour market statistics (Kakinaka and Miyamoto, 2012).

The unemployment rate is the number of jobless people as a share of the labour force. As a proxy for the health of the economy and the effectiveness of current economic policies, the number of people who are now unemployed but looking for work is often used as an indicator (Murphy and Topel, 1997). The unemployment rate is widely used as a leading economic indicator because it provides timely and reliable feedback on the relative success of different macroeconomic strategies in different countries (Nemore *et al*., 2021).

Studying the outcomes of the labour market has long attracted the attention of academics, policymakers and international organizations. The correlation between the labour force participation rate (LFPR) and the unemployment rate is an area of study that has garnered attention. Insights into the nature of the connection between these two factors are crucial for the development and application of macroeconomic theory, economic modelling and labour market policy (Raifu and Adeboje, 2022).

As the unemployment rate may not be a reliable predictor of unemployment due to LFPR fluctuations, it is also important to examine LFPR as a time series (Tansel *et al*., 2016a). The LFPR is a crucial barometer of the state of the labour market in any given country. Increases in economic growth have been linked to increases in the LFPR, while a low LFPR, on the other hand, may point to a high unemployment rate and subsequent economic difficulties. Regulatory shifts and cyclical fluctuations in the economy may affect the LFPR in the future (Özdemir *et al*., 2013). As such, the unemployment rate may not be a reliable indicator of labour market conditions if the LFPR varies with the business cycle (Österholm, 2010).

Both the discouraged-worker effect and the added-worker effect play a role in explaining the significant correlation between the two variables. One way in which negative shocks to the unemployment rate might have an unfavourable effect on persons who are unemployed and looking for work is through the discouraged-worker effect. Since there are not enough employment opportunities, individuals give up looking for jobs and drop out of the labour force. Therefore, according to the "discouraged-worker" hypothesis, there is a negative correlation between the unemployment rate and the percentage of the population that is actively seeking employment (Yildirim, 2014).

On the other hand, an increase in the unemployment rate could lead to an increase in the demand for labour. According to the "added-worker" effect, when the economy is in a downturn and

the unemployment rate suddenly spikes, it may encourage those who were previously outside the labour force to enter it and look for jobs (Congregado *et al*., 2021). When unemployment is high, the added-worker effect states that tertiary workers enter the labour force out of fear of losing their primary source of income or seeing their primary source of income undergo compensation decreases (Lale, 2018).

Another intriguing feature of the relationship between the unemployment rate and the LFPR is the so-called the unemployment invariance hypothesis (UIH). According to the UIH, if more people are actively looking for work, the unemployment rate would be lower. In other words, the UIH believes that adjusting the LFPR will not have a significant effect on the jobless rate in the long term. The UIH assumes that economic growth, worker skills and job availability all play a role in determining the long-term unemployment rate. As these characteristics tend to be consistent over time, the UIH also expects the unemployment rate to do so (Österholm, 2010). Prior research by Kögel (1989) and Layard *et al*. (1991) initially proposed the UIH. These analyses suggested that the unemployment rate is resilient to changes in LFPR, productivity growth and capital stock (Nguyen Van, 2016).

It is believed that shifts in labour supply, demand and wage-setting behaviour account for the disconnection between the unemployment rate and LFPR, productivity growth and capital stock. For instance, the labour supply-demand gap will narrow as a result of the increased demand for labour due to increased capital accumulation or technical advancement. However, the UIH contends that pay-setting behaviour also responds to changes in labour demand and cancels out the falling unemployment rate (see Karanassou and Snower, 2004, for detailed graphical explanations).

The question whether the unemployment rate is related to the amount of labour force participation in economies around the world has been the subject of a growing body of scholarship. As a result, the UIH has been hotly debated in the economics community, with some scholars arguing in favour and others arguing against it.

Some underlying elements may be responsible for the long-run unemployment rate and are immune to changes in these other variables, which is the key argument in favour of the jobless rate remaining steady over time. As a result, the unemployment rate is not influenced by trends in the associated macroeconomic variables. However, there are other arguments against the UIH, such as the idea that it promotes flexibility in the workplace when this may not be the case and that it downplays the importance of expectations (Karanassou and Snower, 2004).

The Korean labour market has experienced significant growth in recent years. The unemployment rate in Korea has risen and fallen over the years, fluctuating dramatically during the 1997 global financial crisis and, according to the Korean Statistical Institute, the monthly unemployment rate has ranged from a high of 3.1% in January 1998 to a low of 2.1% in August 2022.

The Korean job market has also been significantly affected by the ongoing COVID-19 outbreak. Aum *et al*. (2020) reported that, even in the absence of government-imposed lockdowns, employment collapsed in locations with more severe COVID-19 outbreaks. The findings of Goolsbee and Syverson (2021) on lockdowns and decreased expenditures have implications for the economy and labour market. Policymakers need to keep a close eye on these metrics to guide them in making well-informed decisions for the good of the economy and the populace.

Despite these criticisms, the UIH remains an important area of study in economics. Understanding the factors that determine the long-run unemployment rate can help policymakers develop more effective programmes to reduce unemployment and promote economic growth. The existing literature provides mixed evidence, however, on the relevance of the UIH in both advanced and emerging economies. Analysing the existence of cointegration linkages between the two variables in order to assess the three competing hypotheses regarding this relationship is the most typical way to establish whether the UIH is accurate (Congregado *et al*., 2021). In a pioneering empirical study to evaluate this linkage, Österholm (2010) employed Johansen–type cointegration analysis as the empirical methodology, and subsequently, the majority of studies adopted a similar methodology to assess the UIH. To test whether two or more time series are cointegrated, that is, whether they are in a long-run equilibrium relationship, Johansen–type cointegration analysis is applied. The existence of a long-term link between two time series can be inferred from a positive result of the Johansen cointegration test. This implies that shifts in one time series will eventually be mirrored in the other. However, empirical evidence from different countries has been mixed, and previous research appears to be very sensitive to factors such as country-specific context, structural breaks and the possibility of nonlinearities.

By accounting for structural shifts, we examine the long-term correlation between Korea's unemployment rate and the LFPR between June 1999 and January 2023. Consequently, our research makes multiple contributions to the existing body of knowledge. To begin, this research is the first to test the validity of the UIH in the South Korean economy, which has been called a "growth miracle" in the literature because of its exceptional performance in the area of capital accumulation (Liu, 2021). Secondly, while the conventional Johansen cointegration test is used in the analysis, it is supplemented with Fourier terms. In place of the standard dummy variable setup, the introduction of the Fourier terms into the Johansen cointegration technique permits controlling for an arbitrary number of multiple breaks in the cointegration system (Pascalau *et al*., 2022).

The remainder of this paper is organized as follows: The second section reviews the literature, the third section introduces the data and the methodology used, the fourth section provides the empirical findings, and the last section concludes the study.

2. Literature Review

The relationship between unemployment and labour force participation has been extensively studied in the literature; however, the results have been mixed. Most studies have used various econometric techniques, such as cointegration analysis and vector error correction models, to examine this relationship in different countries. Using these empirical tools, some studies support the UIH, whereas others challenge its validity.

Most research on the effectiveness of the UIH in both advanced and developing economies has relied on Johansen–type cointegration analysis. The UIH has been disproved by several studies. For instance, Sterholm (2010) used the Johansen cointegration test on data for Sweden from 1970 to 2008 and discovered a significant cointegration relationship between the two variables, implying rejection of the UIH. Female labour force participation was shown to have been affected by an "added-worker effect" within the study's timeframe. Emerson (2011) determined that the unemployment and labour force participation rates in the United States have a negative long-term association. The findings also hold up in a gender-specific environment, where the discouraged-worker impact for men and the added-worker effect for women are both supported.

Kakinaka and Miyamoto (2012) also discovered a discouraged-worker effect in Japan, in which an increase in the unemployment rate was associated with a decrease in the number of people actively seeking jobs. There is a long-term correlation between the unemployment rate and LFPR in Canada, where Tansel *et al*. (2016b) also found no evidence of the UIH. Canada's labour market showed signs of both the added-worker effect for men and the discouraged-worker effect for women.

On the other hand, some studies have used Johansen–type cointegration analysis and supported the UIH. Tansel *et al*. (2016a) concentrated on the Turkish economy, a developing economy, for both aggregated and gender-specific data from 1988 to 2013. The study concluded that there is no long-term correlation between labour force participation and unemployment rates in Turkey, supporting the UIH. Their findings are consistent with both aggregated and sex-specific data. Likewise, Nguyen Van (2016) found that there is no long-term relationship between the unemployment rate and LFPR in Australia, with results also robust for both male and female workers. Oţoiu and Ţiţan (2016) examined the labour market in Romania from 1996 to 2012 and their research supported the UIH, finding that increases in participation rates do not contribute to a rise in unemployment. Meanwhile, in Spain, Altuzarra *et al*. (2018) supported the UIH for the total and male cases. However, they looked at the substantial gender disparities in the labour force by exploring the long-term cointegration relationship between the unemployment rate and the LFPR for women in Spain.

Yildirim (2014) examined the working conditions of Turkish women between 1989 and 2012 but with a different empirical definition. The study looked for a long-term relationship between the two variables among Turkish women using autoregressive distributed lag (ARDL) bounds cointegration analysis and found none. The author also provided statistics on the level of education attained by women in urban areas. According to the findings, higher levels of education led to higher rates of female labour force participation in Turkey.

Level of development, sample period, gender, the empirical methods used and the presence of structural breaks and demographic groups seem to be important for testing the UIH. Therefore, some of the studies consider structural breaks and possible nonlinearities in examining the link between the unemployment rate and labour force participation. Of these studies, Nemore *et al*. (2021) found strong support for a significant long-run relationship between unemployment and labour force participation, which suggests a persistent added-worker effect for all cases of males and females in Italy. The nonlinear case of the empirical analysis argued that the relationship provides an added-worker effect for females when the LFPR is higher. However, the added-worker effect seems to be at work for the males when the LFPR is lower. Congregado *et al*. (2021) focused on the potential nonlinearities in the relationship between the unemployment rate and LFPR in Poland from 1995 to 2016. They confirmed that the invariance, added-worker and discouraged-worker hypotheses hold true for various demographic groups depending on the regime, despite the fact that their findings were mixed. In light of this, their findings support the long-term connection by considering nonlinearity and structural breaks. Liu (2021) employed a cross-sectional distributed lag model to investigate the potential drivers of unemployment trends across OECD countries, including Korea, in order to draw conclusions about the relevance of the UIH. In the sample countries, they discovered evidence that casts doubt on the utility of the UIH for those in the OECD countries.

In their recent work, Raifu and Adeboje (2022) evaluated the long-term relationship between the unemployment rate and the LFPR in African countries for various categories of labour force, including gender and age, using a variety of cointegration approaches. Except for South Africa, the study revealed that the UIH does not apply to African countries. The most recent work of Claveria and Soric (2023) examined the presence of cointegration between unemployment uncertainty and the unemployment rate in European countries. Their analysis reveals that uncertainty demonstrates a persistent connection with unemployment in the majority of countries. The influence of uncertainty on unemployment is marked by significant disparities, with a stronger response observed when labour market uncertainty decreases. They concluded that there is a substantial reduction in the divergence of consumer expectations regarding unemployment.

The UIH has been tested in various countries and the results have been mixed. Some studies have found that the hypothesis holds, whereas others have concluded the opposite. The differences in the results may be due to country-specific factors and differences in the methodologies and data sources used. Since the findings in the literature are mixed, further research is needed to explore and better understand the relationship between unemployment and labour force participation across different countries and time periods. The impact of potential nonlinearities in a structural break on the nature of this relationship remains an important area for investigation.

3. Methodology and Data

Nonlinear time series can be approximated with Fourier coefficients, which can capture different types of asymmetric adjustments, as shown by Ludlow and Jones (2000). The use of trigonometric terms in time series analysis was also suggested by Becker *et al*. (2004) as a means of identifying structural breaks, seasonality or stochastic fluctuation in coefficients over time. One of the main benefits of the Fourier method, as pointed out by Becker *et al*. (2006), is that the number, position and shape of the structural changes do not need to be determined a priori. In this research, by considering the superiority of the Fourier approach, we use the unit root and cointegration tests that employ a Fourier function.

3.1 Unit root test with a Fourier function

The Dickey-Fuller unit root test does not take into consideration any potential discontinuities. However, after Perron's seminal work in 1989, researchers realized the importance of accounting for potential breaks in their analyses. The Fourier augmented Dickey-Fuller (FADF) test presented by Enders and Lee (2012), which extends the Dickey-Fuller unit root test with a Fourier function to accommodate numerous structural breaks, is one of the most well-known examples of such research.

Enders and Lee (2012) suggest employing the following model in Equation 1:

$$\Delta Y_t = \beta_1 + \beta_2 Y_{t-1} + \delta_1 \sin\left(2\pi kt/T\right) + \delta_2 \cos\left(2\pi kt/T\right) + \sum_{i=1}^{k} \alpha_i \Delta Y_{t-i} + u_t \qquad (1)$$

where t and k denote a trend term and a particular frequency, respectively. The optimal value of k is determined by choosing the value that minimizes the sum of the squared residuals. After determining the optimal k, we first test the null hypothesis of non-significance of the trigonometric terms, $\delta_1 = \delta_2 = 0$, by using a usual F-test statistic. In the case of significance of the trigonometric terms, the null of unit root, $\beta_2 = 0$, can be tested. The necessary critical values were tabulated by Enders and Lee (2012).

3.2 Cointegration test with a Fourier function

The Johansen cointegration test is one of the most popular multivariate techniques used to determine whether two or more nonstationary time series variables are cointegrated. The test is based on the following vector error correction model (VECM), which incorporates both short-term dynamics and long-term equilibrium relationships:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{j=1}^{p} \Gamma_j \Delta Y_{t-j} + \mu + e \tag{2}$$

where Y_t is a $\boldsymbol{g} \times 1$ vector of variables that are integrated of order one, $\Pi = \sum_{j=1}^{p} \mathbf{A}_j - 1$ and $\Gamma_j = -\sum_{i=j+1}^{p} \mathbf{A}_i$ where $\mathbf{A}$'s are ($g \times g$) coefficient matrices. $\prod$ contains the cointegrating relations between the variables, while Γ represents the short-run parameters. The null hypothesis of no cointegration can be tested by determining the rank (r) of the matrix $\prod$, by examining its eigenvalues (λ_i) which are different from zero. If the rank of $\prod$ is zero, we cannot reject the null hypothesis, and Equation (1) becomes the traditional vector autoregressive (VAR) model in the first difference. If $\prod$ has a reduced rank, $rank\ (\prod) < \boldsymbol{g}$, then $\prod$ can be written as $\prod = \alpha\beta$' with both of $\boldsymbol{g} \times \boldsymbol{r}$ vectors. The null hypothesis can be tested using the following test statistics.

and

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln\left(1 - \hat{\lambda}_i\right) \text{ and } \lambda_{\max}(r, r+1) = -T \sum_{i=r+1}^{g} \ln\left(1 - \hat{\lambda}_{r+1}\right) \tag{3}$$

where T is the sample size and $\hat{\lambda}_i$ denotes the estimated value for the i-th ordered eigenvalue. While one can test the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors using the trace test, λ_{max} helps examine the similar null hypothesis against the alternative hypothesis of $r + 1$ cointegrating vectors. The critical values of the tests were tabulated by Johansen (1988, 1991).

The Johansen test is a powerful tool for testing the long-run relationship between the integrated variables. However, the power of the test decreases when structural breaks exist in the cointegration relationship (see Campos *et al*., 1996). Therefore, in addition to the traditional Johansen cointegration test, we also employ the recently introduced VECM-based cointegration test, which augments the Johansen cointegration test with a Fourier function. The inclusion of the Fourier function is owing to its attractive properties, such as capturing the behaviour of an unknown number of multiple breaks in the long-run relationship, and the location of the breaks does not need to be known. To apply the Fourier augmented Johansen–type (Johansen–Fourier) cointegration test, the following model is estimated:

$$\Delta Y_t = \Pi Y_{t-1} \sum_{j=1}^{p-1} \Delta Y_{t-j} + \mu + f_t + e_t \tag{4}$$

where f_t denotes the Fourier function, which can be expressed as:

$$f_t = A \sin\left(2\pi kt/T\right) + B \cos\left(2\pi kt/T\right) \tag{5}$$

where t is the trend term and k represents a particular frequency. The optimal value of k is determined by choosing the value that minimizes the Schwarz information criterion. After determining the optimal k, the trace and maximum eigenvalue statistics for the Johansen-Fourier test are obtained in a manner similar to the Johansen test. Pascalau *et al*. (2022) tabulated the necessary critical values.

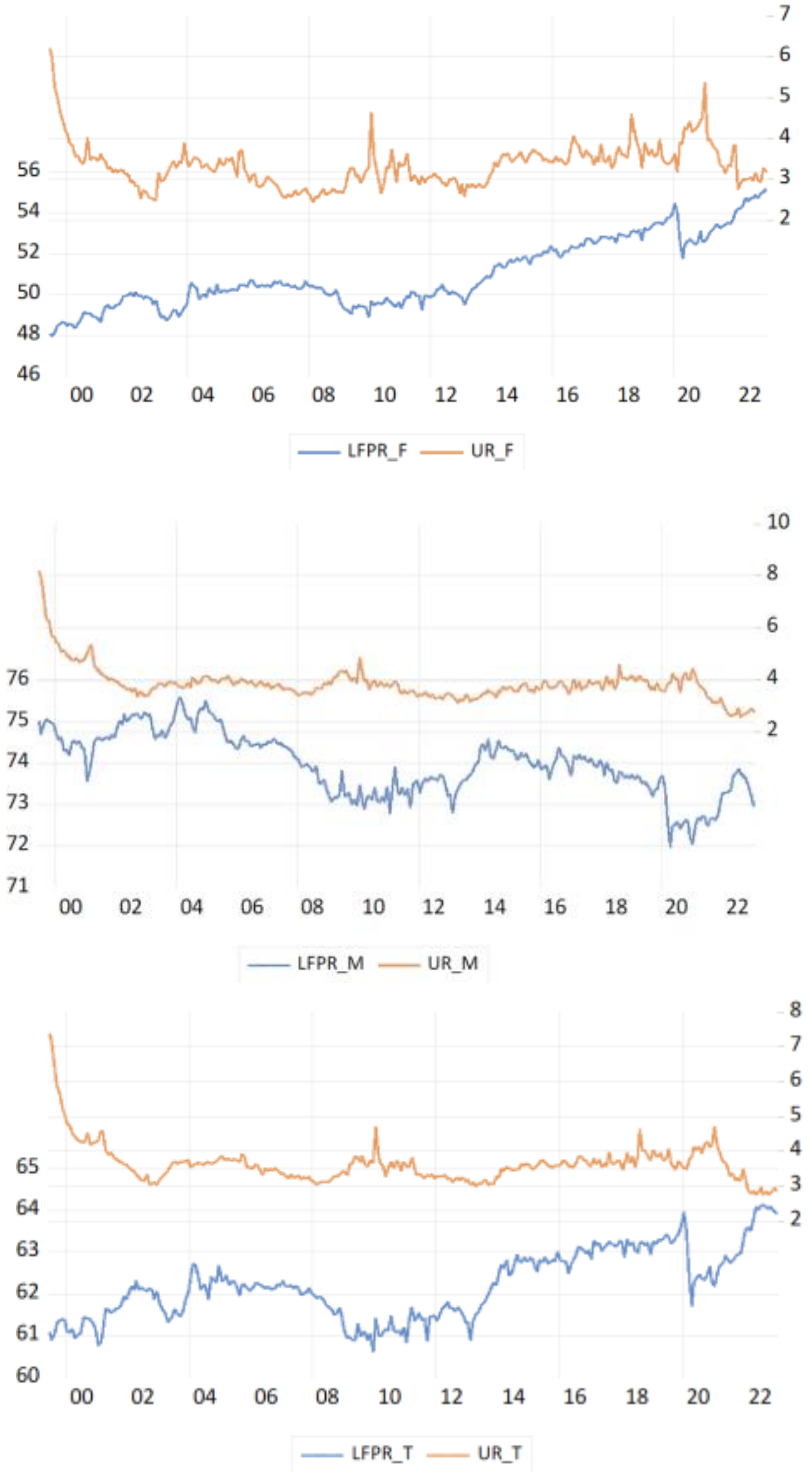
3.3 Data

Our study uses data for the period between June 1999 – January 2023. We obtained unemployment rates and LFPR data for total, male and female participants from the Korean Statistical Information Service website. The data availability determines the beginning and end of the analysis period.

Since the series present a strong seasonal pattern, we adjusted the seasonality of the data using the Census-X12 and employed adjusted series in all our analyses.

The dynamics of the transformed data are illustrated in Figure 1.

Figure 1: Data dynamics



Note: LFPR_F, LFPR_M and LFPR_T represent female, male and overall labour force participation rates, respectively. UR_F, UR_M and UR_T represent the female, male and overall unemployment rates, respectively.

Source: Korean Statistical Institute (2023)

The plots in Figure 1 show that there seem to be some structural changes in the data-generation process. Hence, considering structural changes when testing the unit root behaviour and the relationship between variables may lead to more accurate results.

Next, we present the descriptive statistics of the data and report them in the following table:

Table 1: Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Probability
LFPR_F	50.949	50.387	55.131	47.968	1.671	0.575	2.335	20.908	0.000
LFPR_M	73.975	73.971	75.591	71.993	0.749	−0.150	2.458	4.538	0.103
LFPR_T	62.202	62.162	64.117	60.620	0.812	0.266	2.311	8.976	0.011
UR_F	3.333	3.313	6.190	2.428	0.537	1.499	7.908	391.445	0.000
UR_M	3.844	3.757	8.132	2.551	0.665	2.782	16.408	2493.473	0.000
UR_T	3.631	3.579	7.366	2.746	0.562	2.928	17.352	2843.313	0.000

Source: Korean Labour Statistics. Authors' calculations with collected data (2023)

Table 1 indicates that, on average, a higher percentage of males participate in the labour force compared to females, and the unemployment rate is slightly higher for males than for females. The median values are close to the mean values, indicating a fairly symmetrical distribution for all the data. The standard deviation for LFPR is higher for females (1.67) than for males (0.75), indicating a greater variability in female labour force participation rates; however, the standard deviation for UR is also higher for males (0.66) than for females (0.54), suggesting a greater variability in male unemployment rates.

The skewness for LFPR is positive for females (0.58) and total (0.27) and negative for males (−0.15), indicating that the distribution is slightly skewed to the right for females and total, and to the left for males. The skewness for UR is positive and high for all the categories, indicating a highly skewed right distribution, meaning that there are some periods with very high unemployment rates. The kurtosis for LFPR is below 3 for all the categories, indicating a platykurtic distribution, *i.e.*, the tails of the distribution are thinner than a normal distribution. The kurtosis for UR is higher than 3 for all the categories, indicating a leptokurtic distribution, that is, the tails of the distribution are fatter than a normal distribution, suggesting a higher probability of extreme values.

The Jarque-Bera test is used to determine whether the data follow a normal distribution. The null hypothesis is that the data are normally distributed. Given the probability values, we can reject the null hypothesis for UR in all the categories (as the probabilities are close to 0), indicating that the unemployment rate data are not normally distributed. However, for LFPR, we cannot reject the null hypothesis for males (probability = 0.103) but can reject it for females and total, indicating that the LFPR data are not normally distributed for females and total but normally distributed for males.

In summary, the given descriptive statistics show that, on average, a higher percentage of males participate in the labour force compared to females, and the unemployment rate is slightly higher for males than for females. The LFPR data have a fairly symmetrical distribution, while the UR data are highly skewed to the right. The LFPR data may not be normally distributed for females and total, while the UR data are not normally distributed for all the categories.

4. Empirical Results

The empirical specification of our study depends on testing the empirical relevance of the UIH by examining the long-run relationship between the unemployment rate and LFPR in a cointegration framework. However, running a cointegration analysis requires determining the order of the integration of the employed variables, because the variables must be integrated at first differences to apply the proposed cointegration tests. Therefore, we first apply FADF unit root tests to determine the integration levels of the variables. The findings of the FADF are presented in Table 2.

Table 2: Results of Fourier ADF unit root test

	Intercept			Intercept & trend		
	***F*-test stat.**	**Opt. frequency**	**Test stat.**	***F*-test stat.**	**Opt. frequency**	**Test stat.**
LFPR_F	2.339	1	−1.818 [1]	5.246	1	−3.708 (1)
LFPR_M	5.356	2	−3.362 [2]	8.245 ***	2	−4.717 (1) ***
LFPR_T	2.907	1	−2.813 [1]	2.466	2	−2.891 (1)
UR_F	3.985	1	−4.307 [6]	2.301	1	−4.293 (6)
UR_M	3.962	5	−3.873 [6]	5.258	5	−5.985 (3)
UR_T	4.207	5	−4.169 [6]	4.154	5	−4.149 (6)

Note: *** indicates significance at the 1% level, respectively.

Source: Authors' calculations with collected data

Only the male LFPR series show statistical significance for the Fourier function, as determined by the FADF unit root test. Also, when we add the intercept and the trend term to the test equation, the FADF test statistics offer evidence of stationarity for this series. We additionally employ traditional unit root tests due to the absence of data supporting the stationarity of series. Table 3 displays the outcomes of the conventional unit root tests.

Table 3: Results of unit root tests

	ADF		DF-GLS		KPSS	
	Intercept	Intercept & trend	Intercept	Intercept & trend	Intercept	Intercept & trend
LFPR_F	0.23 (0.974) [12]	–1.756 (0.723) [10]	1.744 [12]	–1.953 [10]	1.712 [14]	0.312 [14]
LFPR_M	–1.396 (0.584) [12]	–2.479 (0.338) [12]	–0.51 [12]	–2.521 [12]	1.113 [14]	0.125 [14]
LFPR_T	–1.215 (0.669) [12]	–2.07 (0.56) [12]	0.122 [12]	–2.116 [12]	1.179 [14]	0.224 [14]
UR_F	–2.736 (0.069) [12]*	–3.062 (0.118) [12]	–0.265 [12]	–1.472 [12]	0.348 [13]	0.244 [13]
UR_M	–2.447 (0.13) [9]	–3.07 (0.116) [12]	0.643 [12]	–1.361 [12]	0.781 [13]	0.184 [13]
UR_T	–2.893 (0.048) [9]**	–3.133 (0.101) [13]	0.303 [8]	–1.407 [8]	0.39 [13]	0.212 [13]

Note: * and ** indicate significance at the 10 and 5% levels, respectively.
Source: Authors' calculations with collected data

The empirical findings of the augmented Dickey-Fuller (ADF) unit root test for the intercept case indicate that the female unemployment rate and the total unemployment series are stationary at their levels because the null hypothesis of nonstationarity is rejected for these series. The "intercept & trend" case for all the variables in the ADF, Dickey-Fuller generalized least squares (DF-GLS) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests, however, provides proof that none of the series are stationary at their level values. In other words, the null hypothesis of nonstationarity cannot be rejected in the ADF and DF-GLS tests. The KPSS test rejects the null hypothesis that all the series are stationary. Therefore, upon evaluation of the results from all unit root tests, it can be concluded that all the series exhibit unit root characteristics.

Since all the series are confirmed to be integrated at 1, the next stage in our empirical research is to perform a cointegration analysis. The Johansen cointegration test results for the total male and female population are presented in Table 4 below. This test investigates the long-run link between unemployment and labour participation rates.

Table 4: Johansen cointegration tests

	Total ($p = 2$)		Male ($p = 4$)		Female ($p = 2$)	
	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}
H_0: $r = 0$	42.984***	43.610***	32.486***	32.730***	30.878***	33.706***
H_0: $r = 1$	0.626	0.626	0.244	0.244	2.828	2.828

Note: *** denotes significance at the 1% level. "*p*" shows the optimal lag lengths chosen using the Schwarz information criterion.

Source: Authors' calculations with collected data

The maximum eigenvalue (max) and trace (trace) statistics are offered by the empirical results of the Johansen cointegration test. Both trace statistics and maximum eigenvalue statistics start with the premise that the number of cointegrating vectors in a system is exactly *r*. Our results provide empirical support for the existence of a single cointegration relationship.

However, Hjalmarsson and Österholm (2010) suggested that if one of the variables has a near unit root, then these test statistics have size distortions and provide a spurious cointegration relationship. Therefore, they offer to test the restrictions of $\beta = (1, 0)'$ and $\beta = (0, 1)'$. In this case, the rejection of both restrictions supports evidence of a cointegration relationship; otherwise, we can conclude that cointegration exists because of the stationarity of one variable in the setting. Table 5 displays the results of the test for these restrictions.

Table 5: Tests of restrictions in cointegrated VAR

Restriction	Total	Male	Female
$\beta = (1, 0)'$	37.784***	26.435***	24.485***
$\beta = (0, 1)'$	40.582***	29.151***	26.625***
$\alpha = (\alpha_1, 0)'$	0.596	2.658	5.575**
$\alpha = (0, \alpha_2)'$	39.757***	31.269***	20.891***

Note: *** and ** denote significance at the 1% and 5% levels, respectively.

Source: Authors' calculations with collected data

These findings provide credence to the dismissal of both constraints. Therefore, in every instance, we may conclude that these variables are significantly cointegrated in the long run.

According to the standard Johansen cointegration method, our findings suggest that the Korean labour market does not support the UIH. Our results are consistent across genders, as the cointegration relationship is validated for both sexes.

We also test the hypotheses concerning the adjustment coefficients to analyse short-run dynamics. The restrictions can be denoted as $\alpha = (\alpha_1, 0)$' and $\alpha = (0, \alpha_2)$'. The latter restriction indicates that LFPR does not error-correct, but UR does, whereas the former suggests that UR does not error-correct, but the LFPR does. We could not reject the first restriction for all the considered relationships except for females, which shows that UR does not adjust the LFPR for all types of series except for females. However, we reject the second restriction for all types of unemployment rates, implying that the LFPR is not weakly exogenous for all types of relationships.

We use the Johansen-Fourier cointegration test to examine the long-term link between unemployment and labour force participation, given that this relationship is vulnerable to structural disruptions. The robustness of the analysis may be evaluated thanks to the inclusion of potential structural breaks. Johansen-Fourier cointegration test outcomes are shown in Table 6.

Table 6: Johansen-Fourier cointegration test

	Total ($p = 2, k = 5$)		**Men ($p = 2, k = 5$)**		**Women ($p = 2, f = k$)**	
	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}
$H_0: r = 0$	55.284***	55.837***	56.784***	57.387***	33.388***	35.189***
$H_0: r = 1$	0.554	0.554	0.604	0.604	1.801	1.801

Note: *** denotes significance at the 1% level. "*p*" and "*k*" shows the optimal lag lengths and frequencies, respectively.

Source: Authors' calculations with collected data

As is the case in the traditional Johansen cointegration setting, the empirical findings of the Johansen-Fourier cointegration analysis also provide evidence favouring the existence of one cointegration vector[1]. As noted, to test whether any of the variables are near unit roots so they manipulate the cointegration relation between variables, we test the restrictions in the VAR model and obtain the results in Table 7.

1 We also apply the Johansen–Fourier cointegration test using multiple frequencies. The findings support the evidence of a cointegration relationship; we provide the results in the Appendix.

Table 7: Tests of restrictions in cointegrated Fourier-VAR

Restriction	Total	Male	Female
$\beta = (1, 0)'$	50.088***	49.670***	0.287
$\beta = (0, 1)'$	52.900***	53.356***	29.427***
$\alpha = (\alpha_1, 0)'$	1.237	0.135	1.684
$\alpha = (0, \alpha_2)'$	50.294***	55.964***	28.846***

Note: *** denotes significance at the 1% level.
Source: Authors' calculations with collected data

As noted, the rejection of both restrictions provides evidence of a significant cointegration relationship. In the Fourier-VAR setting, we reject both restrictions for the overall labour market and for males. Therefore, we can conclude that unemployment and labour force participation are cointegrated for the entire Korean labour market and for male workers. However, for the female labour force, we cannot reject the $\beta = (1, 0)'$ restriction. Thus, we can conclude that the cointegration relationship is due to a stationary variable for female workers, which is the unemployment rate in this case. Therefore, our findings provide evidence for the existence of the UIH for the female workforce on the Korean labour market.

In addition, we test the restrictions on the error correction terms. While we cannot reject the $\alpha = (\alpha_1, 0)'$ in all the cases, we can reject the $\alpha = (0, \alpha_2)'$ in all the cases, which confirms that the LFPR series are weakly exogenous in all the cases.

Overall, our results indicate a cointegration relationship between aggregate labour force participation and unemployment rates in both the traditional Johansen cointegration setting and with the incorporation of potential structural breaks into the analysis. Therefore, these findings imply that the long-run unemployment is not independent of the labour force in Korea.

To confirm this relationship, we also analysed gender-disaggregated data. Strong evidence against the UIH for both sexes is provided by the standard Johansen cointegration study. However, proof that the UIH is true for females but useless for males is provided by the inclusion of structural breakdowns in the Johansen-Fourier cointegration analysis. Therefore, the results of the latter study corroborate the UIH for women in Korea, suggesting that long-term unemployment among women is unrelated to their participation in the labour force. The empirical results have substantial ramifications for labour economics academics and policymakers in Korea. Unemployment rates and labour force participation have been shown to be significantly cointegrated, highlighting the need to take them both into account when designing labour market strategies. Recognizing

the correlation between unemployment and workforce engagement would help policymakers craft more effective policies.

Furthermore, the lack of backing for the UIH indicates that shifts in labour force participation alone cannot account for long-term patterns in the unemployment rate. This conclusion illustrates the complexities of the labour market and suggests that variables other than structural shifts, technological progress and policy interventions may play important roles in determining long-run unemployment patterns.

On the one hand, our findings from the traditional Johansen cointegration analysis are consistent with the findings of Österholm (2010) for Sweden, Emerson (2011) for the United States and Tansel *et al*. (2016a) for Canada. However, our findings contradict those of Tansel *et al*. (2016b) for Turkey and Alturazza *et al*. (2018) for Spain. On the other hand, our analysis, which considers structural breaks, is mostly in line with Kakinaka and Miyamoto (2012) for Japan and Nemore *et al*. (2021) for Italy.

5. Concluding Remarks

This study used two types of cointegration tests to investigate the long-term connection between Korea's unemployment rate and the LFPR from June 1999 to January 2023: the standard Johansen cointegration test and the Johansen-Fourier cointegration test, which takes into account the possibility of structural breaks. Our study adds to the current literature methodologically because we accounted for structural breaks using Fourier terms. Nonlinearities and structural changes in the relationship were taken into account for a thorough analysis.

The findings shed light on the influence of changes in worker status on labour market data and improve our understanding of the intricate link between unemployment and LFPR. The results emphasize the significance of LFPR dynamics in variations to the interpretation of the unemployment rate.

Long-term unemployment does appear to be linked to labour force participation, as the data show that the UIH does not hold for the whole Korean labour market. In addition, gender-specific data analysis is provided, leading to the conclusion that the UIH is supported by Korean women but not Korean males. This discrepancy highlights the gender-related difficulties on the South Korean labour market, which may be attributable to variations in industry, the distribution of part-time jobs and structural flaws.

Overall, the manuscript contributes to the expanding body of information on the intricacies of the unemployment-LFPR relationship across different countries, presenting nuanced findings that both confirm and challenge the conclusions of earlier research. The findings highlight the need

to examine this fundamental facet of the labour market while taking into account country-specific characteristics, structural breaks and nonlinearities.

The study urges for more investigation into the link between unemployment and labour force participation in light of the contradictory findings across countries and research methods. These findings can help policymakers develop better approaches to lowering unemployment and boosting economic growth. Researching and managing labour market dynamics is essential for achieving long-term economic growth as the global economy evolves.

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Appendix

Table A: Johansen Fourier cointegration test with cumulative frequencies

	Total ($n = 2, p = 2$)		**Men ($n = 2, p = 2$)**		**Women ($n = 2, p = 1$)**	
	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}
$H_0: r = 0$	61.030***	68.730***	48.549***	73.605***	50.055***	53.770***
$H_0: r = 1$	7.700	7.700	25.056	25.056	3.715	3.715

Note: *** denotes significance at the 1% level. "*p*" and "*n*" shows the optimal lag lengths and number of cumulative frequencies, respectively. The critical values at the 1% and 10% levels are 44.952 and 34.367, respectively.

Source: Authors' own calculations