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Validity of the Phillips Curve in the Agricultural Sector and Asymmetric Effects: The Case of Türkiye

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ABSTRACT

Although the employment share of agriculture, which has historically been the main job creator sector, has decreased over time, it still plays an essential role in newly industrializing countries such as Türkiye. However, the depth of the decline in employment is due to the economic impact of agriculture rather than its share of GDP. One way to measure this effect is to adapt the Phillips curve (PC) for the agricultural sector. Therefore, the aim of this study is to investigate the validity of the Phillips curve in the Turkish agricultural sector and the short- and long-term linear and non-linear relationships caused by shocks on unemployment-inflation. The study was conducted via the augmented Dickey-Fuller, Phillips-Perron, and Zivot-Andrews unit root tests as well as the autoregressive distributed lag model (ARDL) and the nonlinear autoregressive distributed lag model (NARDL) via the Turkish Statistical Institute's (TURKSTAT) 2014Q1-2021Q3 dataset. The cointegration coefficient was negative, yet statistically significant. Also, the short-term imbalances were eliminated, and the system converged to the equilibrium values in the long-run with significant fluctuations. The long-run negative cointegrated relationship and PC validity in negative shocks are the most significant results of the study.

Keywords**:** Inflation, Unemployment, ARDL-NARDL, Negative shocks, Negative long-run cointegration

1. Introduction

Inflation and unemployment are two economic problems that are closely associated and thought to have the most mutual interaction among the concepts of growth, unemployment, and inflation that are accepted as the most three essential indicators in macroeconomics literature. In the literature, the approach to estimate the inflation-unemployment relationship via the Phillips curve method has a wide research base. Despite the decades that have passed since the original Phillips curve was created, the relationship that has developed continuously and remained as one of the main arguments of policy makers still maintains its validity today. Therefore, governments are often keen to determine the optimal combination of unemployment and inflation. In this regard, in Türkiye, where high inflation has been experienced for many years, combating inflation and unemployment has been one of the main objectives of government programs. However, this relationship did not receive critical attention until the astronomical increase in agricultural product prices experienced in the recent period in Türkiye, and even scientific studies in this area remained considerably penurious. The main motivation for this study is the curiosity about whether the Philips curve, which has obvious practical importance yet has barely been studied for the agricultural sector in the literature, is valid in the recent era. It is also essential to carry out both linear and non-linear studies in agriculture in terms of revealing the effects of shocks and having a different policy-developer perspective to reduce unemployment in the agricultural sector.

Thus, the purpose of this study is to investigate the unemployment-inflation relationship through the validity of the Phillips curve and asymmetric effects between 2014 and 2021 in Türkiye when food price inflation became more noticeable. In this context, unemployment in the agricultural sector and the rates of price increases agricultural products were compiled from the Turkish Statistical Institute (TURKSTAT) database and the relationship between them was analyzed by employing the nonlinear autoregressive distributed lag (NARDL) and autoregressive distributed lag (ARDL) tests.

The nexus of price changes, unemployment, and the level of production discussions that started with Humphrey (1986) gained a different basis with the empirical evaluation of the subject in the 20th century. In 1926, Irving Fisher found a strong causal relationship between price changes and employment due to the costs are lagged adjusted to changes in prices. However, Tinbergen (1936), in the first researcher-conducted econometric study, determined causality from unemployment to wage inflation due to demand pressure in the labor market. Moreover, the relationship between wage inflation and unemployment rate was diagramed by A. J. Brown (1955), but the stable tradeoff was first plotted by P. Sultan (1957).

A.W. Phillips conducted a study in 1958 to determine the relationship between nominal wages and unemployment rates in the British economy. He calculated via simple regression the existence of a long-run, negative, and non-linear static relationship between money wages and unemployment rate in three different periods (1861-1913, 1913-1948, and 1948-1957) in which there were structural breaks. In other words, he, like his predecessors, examined the relationship between nominal wages and unemployment rate and, like other researchers, detected the inverse and non-linear relationship. However, Phillips differed from their findings not in that he proved or drew the relationship with the data, but that he found the high frequency and inversely correlated relationship was stable (Frisch 1977). Two years after the publication, Samuelson & Solow (1960), slightly differentiating Phillips' work, and examined the relationship between inflation and unemployment variables for the United States. The designed equation was as follows:

$\pi_t = \propto - \gamma(U_t - U^*)$ π_t - current inflation, $\propto$ - position of the curve

Where; γ - coefficient is the ratio of inflation to the deviation of unemployment from the natural rate, Ut - current unemployment rate, and U^* - the natural rate of unemployment. A negatively sloped curve that is referred to as the Phillips curve in the literature that presents the negative relationship between inflation and unemployment was structured (Samuelson & Solow 1960).

Until the late 1960s, this approach was used and considered quite frequently in estimating how wages and prices might be used to offset each other since orthodox Keynesian economists thought that the curve represented a stable relationship valid in both the short and long run (Akkuş 2012). Lipsey (1960) found a negative relationship between monetary wages and the unemployment rate in the analysis based on the relationship between excess demand in the labor market and money wages and the same surplus and unemployment rate in the same market. So, according to this type of Keynesian thought (that was surprisingly in favor of the Samuelson-Solowian framework rather than the original Phillipsian approach), a realistic and permanent decrease in unemployment could only be achieved by putting up with an increase in inflation levels. The reason why the Phillips curve was easily accepted by the orthodox Keynesian view was that this view believed in the strong explanatory power of the investment-saving and liquidity preference-money supply (IS-LM) model including the concepts of inflation and market price (Mankiw 1990).

However, with the reduction of world oil supply in the early 1970s, an unprecedented rise in the price of oil and petroleum products caused the production volume to decline due to scarcity of resources as well as the shrinking demand due to prices. The decline in production volume decreased the demand for labor, and layoffs increased. Hence, the validity of the Phillips curve was weakened by the stagflation and was subjected to many criticisms. The theoretical and practical inadequacy of the Phillips curve has led economists to seek new economic solutions. M. Friedman (1968) and E. S. Phelps (1967) made the initial criticisms as well as new interpretations. Independently of each other, they included adaptive expectations in the Phillips' literature and caused a paradigm shift in the field (Mankiw 1990). The essential criticism of these two scholars is that the Phillips curve does not take expectations into consideration, but monetarists accept that inflation expectations depend on past inflation rates (Dornbusch et al. 2016). In a wage bargain, when the expected and actual inflation rates are initially the same, the Phillips curve will shift upward in the short run since a move to reduce the unemployment rate will push the expected inflation above the actual inflation rate, and this situation will continue until the unemployment rate is equal to the equilibrium unemployment rate. Therefore, the long-run curve will always remain vertical at the natural rate of unemployment, and unemployment remains constant in the long run at its natural rate (Gordon 2018). The confirmation of the monetarists' propositions in the 1970s caused governments to rely less on the curve.

On the other hand, new classical economists reject the adaptive expectation hypothesis, which is based on the assumption that economic decision-makers fail and constantly repeat their mistakes when analyzing the information they have, arguing that the hypothesis is not based on the micro-foundations of economics (Tokatlıoğlu & Özturk 2015). They believe in the optimization of individuals and the clearing of markets since their goal was to rebuild macroeconomics starting from the microeconomic primitives of choice and technology (Mankiw 1990). According to their rational expectations theory, economic agents use all the information available, not just that from previous periods (Muth 1961), because it is uncertain if the previous period information flow will lead to definite future results (Parkin 2011). Therefore, individuals benefit from learning from each mistake and not making the same mistake again. Hence, Lucas (1972) included rational expectations in the analysis because expected inflation is a mix of the information that economic agents had in the previous period and the information they have in the current period ($\dot{P}_t^e = (\dot{P}t \mid \Omega t - 1)$). This study presents this theoretical background in depth in order to clarify which school's view in the literature is closer to this study's findings while testing the validity of the Phillips curve for the agricultural sector.

The Phillips curve comes to the fore during unemployment-inflation trade-off discussions in agriculture, which is a sector that is very sensitive to increases in the general level of prices and changes in the underproduction capacity. In fact, the original Phillips curve developed its analysis from agricultural production. The Phillips curve model suggests that the increase in the general level of prices resulting from the increase in domestic agricultural product prices has no effect on the nominal wage change rates. Because changes in imports and food prices affect the cost of living, this is reflected in wages. When imports and food prices are excluded from the system, the increase in the rate of change in monetary wages in years when the retail price index is high appears to be cost related. In this context, the only exceptions to the monetary wage-unemployment relationship are imports and the price-wage spiral (Phillips 1958).

When agriculture is evaluated in light of this information, many factors from imports to the price-wage spiral affect the sector. To define the agricultural sector as it is most widely accepted in the literature, it is a labor-intensive field that is shaped according to geographical conditions and that has intensive use of inputs and tools diversified depending on technology. Tools such as tractors or harvesters, which replaced the ox-scythe duo used in the past to cultivate-harvest agricultural land, also left the industry dependent on gasoline-derived energy. This state of dependency, which is seen not only in production but also in the transportation of the final products, created fluctuations in energy prices, and this cost increase in the prices of agricultural products caused an upward movement. Moreover, the intermediate goods are affected by exchange rate increases and the high level of indirect taxes, which are two other factors in the production cost increase. The impact of these cost increases on the level of coverage of wages and product prices is disturbing in that they directly affect three goods groups for public consumption: food, rent, and transportation. Within the researched years, food and transportation expenditures in Türkiye are the first two expenditures in the consumer price index (CPI) (TURKSTAT 2022). In reality, the increase started in 2002, and thereafter, the prices of food products in international markets have increased continuously due to extreme climate changes. The fact that the imbalance between supply and demand is not unique to Türkiye has led to discussions in the foreign literature that food prices will compete with or even surpass oil prices in the future (eg. Baumeister & Kilian 2013). Additionally, with “the abolition of import taxes on agriculture and/or the reduction of the import tax rate” (Martin 2011) in Türkiye, many agricultural products cannot be produced profitably to meet domestic consumption. Also the synthetic price increases of the sellers in the Turkish food sector, which has an oligopolistic structure, adversely affect the entire supply process of agricultural products from the field to the table.

Fundamentally, since agricultural activities mostly involve domestic or seasonal work, labor contracts are short and lead to post-harvest unemployment. Due to the structural transformation experienced after 1980 in Türkiye, the sectoral structure of employment has changed, and the agricultural sector has regressed. This regression continued and deepened in the 1990s and 2000s. On the other hand, the declines in the GDP and employment in the agricultural sector become ordinary when the development level of the country increases. However, the search for profit above the cost increases has also caused the people engaged in agriculture to migrate and give up the land and goods they used in the agricultural sector. This process played an essential role in the increase in the general level of prices due to the shortage of supply. Therefore, the expected situation for countries such as Türkiye is that as Phillips (1958) stated, the analysis cannot be valid in an agricultural sector where imported products, synthetic price increases, and wage increases due to cost increases are intense. Yet, in the absence of these obstacles, the curve becomes valid.

As mentioned in the preceding section, Tinbergen is crucial to the subject of the Phillips curve because he was the person who conducted the first econometric study on unemployment and inflation. Another important aspect of Tinbergen’s research is that his aim was to bring optimal solutions especially to the public sector. Efforts of employment-price relationship modelling gained importance through Tinbergen’s policy implications for an agricultural country such as Holland and for developing countries that were once dominated by the agricultural sector such as Türkiye. Since the causality in the price-employment relationship moves from unemployment to wage inflation due to the demand pressure from the labor market in such countries, the transformation initiated by Tinbergen has accelerated.

According to TURKSTAT (2022), the agricultural sector created employment for nearly a quarter of the workforce from 2014-2021. Theoretically, it is likely that agriculture’s share of GDP will decrease relatively as national economies get stronger, yet, in Türkiye, the sectoral share of GDP related to agriculture was considerable and ranged between 6% and 7% from 2014 to 2021 (TMFA 2022). This stable structure can be explained both by the claim that the country is an agricultural country and by the role of the state in agriculture. From 1923 to the end of the 1970s, Türkiye adopted state-supported agricultural policies. However, while the main purpose of agriculture in the state-supported period was centered on the production of strategic products, the nutrition of society, and the storage and protection of goods, the government support provided to agriculture was deliberately reduced and resources were mostly used in the industrial and service sectors after 1980. But, in the 1980s, the agricultural sector was considered in the framework of food security, agricultural revenue, and supply and pricing of agricultural products, rather than providing economic development or contributing to development. For this reason, the evaluation of the Phillips curve—which was structured econometrically by Tinbergen, developed with Phillips and Samuelson-Solow, and shaped by the Monetarist and New Classical movements—in terms of the state-supported agricultural sector in Türkiye is important because of its economic return and employment share. Thus, it is unsurprising that many studies have examined the validity of the Phillips curve in the economies of various countries, but surprisingly few studies have analyzed its validity for the agricultural sector, especially in the case of Türkiye. For this reason, this study presents chronologically domestic and foreign studies investigating the validity of the Phillips curve econometrically.

The first group presented in Table 1 investigates the relationship between inflation and unemployment.

Table 1- Studies on the Validity of the Phillips Curve

Author	***Year***	***Data Range***	***Country***	***Result***
Uysal & Erdoğan	2003	1980-2002	Türkiye	The Phillips Curve for 1990-2002 is valid.
Kuştepeli	2005	1980-2003	Türkiye	Phillips Curve is not valid
Önder	2006	1987-2004	Türkiye	Phillips Curve is not valid
Hepsağ	2009	2000-2007	Türkiye	In the long run, the Phillips Curve is valid.
Arabacı & Eryiğit	2012	1991-2010	Türkiye	Phillips Curve is valid
Mangır & Erdoğan	2012	1990-2011	Türkiye	Phillips Curve is not valid
Bayrak & Kanca	2013	1970-2010	Türkiye	While the Phillips Curve is invalid in the long run, it is valid in the short run.
Şentürk & Akbaş	2014	2005-2012	Türkiye	There is a bidirectional causality relationship between inflation and unemployment.
Öztürk & Emek	2016	1997-2006	Türkiye	Phillips Curve is valid
Göçer	2016	2005-2015	Türkiye	Phillips Curve is valid
Tabar & Çetin	2016	2003-2016	Türkiye	Phillips Curve is not valid
Alper	2017	1987-2006	Türkiye	Phillips Curve is valid
Saraç & Yıldırım	2017	2005-2016	Türkiye	Phillips Curve is valid
Eygü	2018	1990-2017	Türkiye	Phillips Curve is valid
Özer	2020	2006-2017	Türkiye	Phillips Curve is valid
Polat	2019	2008-2017	Türkiye	Phillips Curve is valid
Salman & Uysal	2019	2006-2018	Türkiye	Phillips Curve is not valid
Kayacan & Birecikli	2020	1998-2016	Türkiye	Phillips Curve is not valid
Şengönül & Tekgün	2021	2005-2011	Türkiye	Phillips Curve is valid
Ozan & Bakırtaş	2021	1995-2019	Türkiye	Phillips Curve is valid
Uğur	2021	1993-2018	Türkiye	Phillips Curve is not valid
Yıldız	2021	2006-2020	Türkiye	Phillips Curve is not valid

In sum, there is no consensus on the validity of the Phillips curve. In fact, the research methods used in these studies are also different from each other. For instance, Uysal & Erdoğan (2003) and Göçer (2016) examined the validity of the Phillips curve for Türkiye by using Granger causality analysis. However, Şengönül and Tekgün (2021), Ozan & Bakırtaş (2021), Hepsağ (2009), and Alper (2017) reached similar results by employing the ARDL boundary test approach. The validity of the curve for Türkiye has also been established by Eygü (2018) and Özer (2020) via the OLS method; by Ozturk & Emek (2016) via unit root ADF and co-integration tests; by Arabacı & Eryiğit (2012) via linear and non-linear regression tests; by Şenturk & Akbaş (2014) via Zivot-Andrews unit root tests with structural breaks and bootstrap causality tests; by Saraç & Yıldırım (2017) via a Markov-switching test; and by Polat (2019) via panel data analysis.

On the other hand, there are several other studies that claim the invalidity of the Phillips curve in the case of Türkiye. In fact, there is no unity in research method and style among this group just as there was no unity among those who defend the validity of the curve. For example, while Kuştepeli (2005) claimed that the curve is not valid for Türkiye based on the results she obtained from linear and non-linear regression analysis, Önder (2006) made the same determination with structural breaks and Markov-switching tests. Similarly, the invalidity of the curve for Türkiye was supported by Mangır & Erdoğan (2012) with causality analysis; by Tabar & Çetin (2016) with structural break tests; by Salman & Uysal (2019) with VAR tests; by Kayacan & Birecikli (2020) with unobserved compositional models; by Uğur (2021) with the panel causality test; and by Yıldız (2021) with Toda-Yamamoto causality analysis. Among these two groups, only Bayrak & Kanca (2013) reported a bilateral finding with short-term validity and long-term invalidity in their analysis using cointegration and OLS tests.

Although unemployment and inflation are a general problem for Türkiye, they are also a substantial agricultural economic problem with the presence of seasonal and permanent workers, the unemployed, and the increase in food prices both locally and globally. In addition, we determined that the unemployment and inflation studies related to the agricultural sector in Türkiye have been conducted bilaterally or discussed under the framework of unemployment hysteria while we were conducting a literature review for this study. Since there are very few studies on the validity of the Phillips curve in agriculture, we will present all national and international studies in this section.

The earliest studies in this area date back to the early 2000s. In the study by Terzi & Oltulular (2004), they determined by Granger causality analysis a negative relationship between inflation and unemployment between 1923 and 2003 in three sectors, namely agriculture, industry, and services. Similar results were also found in the study of Bilman (2008) conducted on the validity of the Phillips curve between 1990 and 2008 using the Hodrick–Prescott filter and Markov-switching model. In the study, although the labor force participation rate in Türkiye was gradually decreasing, the authors claimed that the reason for this was the inability to create an employment environment that would allow the increasing population to work, especially in non-agricultural sectors. Additionally, the study found that although unemployment increased even in the agricultural sector, the general level of prices increased and the curve was valid.

Özaksoy (2015) investigated the validity of the Phillips curve between 1955 and 2014 with the ARDL method within the framework of the minimum underemployment rate (MURI) approach by taking agriculture as a variable of the Turkish labor market. The basic logic of MURI is the analysis of the backward-curved Phillips curve. The slope and inflection points of this Phillips curve depend on how quickly workers show real-wage resistance. If workers resist real wages, even at low wage levels, the Phillips curve will become steeper, and relatively low inflation will reverse at a high unemployment rate. Although there is evidence for the existence of a negative relationship between inflation and unemployment in Türkiye in the long run, the findings have not been explained in terms of agriculture specifically.

Şengönül & Tekgün (2021), previously mentioned above in the first group of Phillips curve studies, dealt with the agricultural sector in a very limited part of their studies. In their research by regions, they figured that since 16 regions were rural areas engaged in agriculture and animal husbandry, inflation and unemployment in these regions showed trade-offs in accordance with the Phillips curve theory.

Similar to Türkiye, there are very few researchers who have directly investigate the relationship between the agricultural and the Phillips curve throughout the world. And not surprisingly the vast majority of those researchers choose the agricultural sector as a subject in the sectoral sense. The reason of not researching agriculture in terms of the curve comes from its structure. Agriculture mostly dependents on climatic conditions and includes the seasonal worker factor.

In Table 2, there are several selected foreign studies that relate agriculture and the Phillips curve. Only those that are marked with (**) have made evaluations directly and specifically in the field of agriculture. The rest of the studies have made analyses by considering agriculture together with other sectors.

Table 2- Studies dealing with both Agricultural Sector and Phillips Curve

Author	*Year*	*Data Range*	*Country*	*Result*
Geary & Jones**	1975	1953-1972	Ireland	PC is weakly valid
Miroljub	1989	1965-1985	Yugoslavia	PC is not valid
Dua & Gaur	2009	1990-2005	Japan, Hong Kong, Singapore, Philippines, Thailand, China, India	PC is valid
Imbs et al.	2011	1978-2005	France	PC is valid
Durevall & Sjö**	2012	2000-2010	Ethiopia and Kenya	PC is valid
Pogorelyy	2013	2003-2013	U.S.A	PC is valid
Mawejje & Lwanga	2015	2000-2012	Uganda	PC is not valid
Ochuodho & Lantz**	2015	2006-2051	Canada	PC is valid for 2006-2015
Duncan et al.	2019	2006-2016	Kenya	PC is valid
Sasongko & Huruta	2019	1984-2017	Indonesia	PC is not valid
Hirata et al.	2020	2003-2017	Japan	PC is valid both in the short-run and in the long-run
Hyder & Hall	2020	1973-2013	Pakistan	PC is valid

** represents the papers which made analyses solely on agriculture

As can be seen, Durevall & Sjö (2012) for Ethiopia and Kenya, Pogorelyy (2013) for the United States, and Ochuodho & Lantz (2015) for Canada have claimed that the Phillips curve is valid in the agricultural sector. Of the studies that solely worked on the relationship between agriculture and the Phillips curve, Geary & Jones (1975) indicated a rather weak relationship for

Ireland. Also, Miroljub (1989) explained that this relationship was not valid for Yugoslavia in the 1965-1985 period, with prices and the general level of employment being determined by the central planning administration.

The general opinion about the validity of the Phillips curve in the agricultural sector also exists in studies that tested the validity of the Phillips curve in the agricultural sector along with other sectors. Dua & Gaur (2009) for Japan, Hong Kong, Singapore, Philippines, Thailand, China, and India; Imbs et al.(2011) for France; Duncan et al.(2019) for Kenya; and Hyder & Hall (2020) for Pakistan all determined the negative trade-off between unemployment and inflation. Conversely, Mawejje & Lwanga (2015) and Sasongko & Huruta (2019) insisted on the invalidity of the curve in terms of agricultural inflation and unemployment for both Uganda and Indonesia. However, Hirata, Maruyama, and Mineyama (2020) conducted a study on Japan that revealed a different result compared to the rest. These authors declared the validity of the curve in the short term yet invalidity in the long term. The inability to reach a consensus among the studies mentioned above, both in Türkiye and abroad, reinforces the curiosity about the findings of this study.

2. Material and Methods

We constructed inflation and unemployment data sets for the period 2014Q1-2021Q3 in the agricultural sector by employing the data pool of TURKSTAT. Specifically, we collected agricultural inflation data through the "Agricultural Products Producer Price Index According to Twelve-Month Averages (%) (AINF)," and we retrieved agricultural unemployment data via the "Monthly Agricultural Unemployment (AUR)." The agricultural unemployment figures were used to represent unemployment rates in the Phillips curve, while for the inflation rate, the logarithms of the agricultural price index values were taken and shown with the abbreviations of *loginf* and *logun*.

The model used to measure the validity of the Phillips curve in the Turkish agricultural sector is given in Equation 1.

$$loginf = \beta_0 + \beta_1 logun + \mathcal{E}_t \quad (1)$$

The descriptive statistics of the variables are presented in Table 3, and the graphs by level values are shown in Figures 1 and 2.

Table 3- Descriptive Statistics and Tests

Descriptives	***loginf***	***logun***
Mean	4.855797	11.23005
Median	4.781904	11.20934
Maximum	5.412185	11.88581
Minimum	4.453258	10.53269
Std. Dev.	0.290554	0.269958
Skewness	0.448119	0.145515
Kurtosis	1.934917	3.836660
Jarque-Bera	2.502792	1.013569
Probability	0.286105	0.602430
Observation	31	31

As can be seen from Table 3, the data have a normal distribution, as the Jarque Bera statistic indicated. Also, Figure 1 presents the CPI index, showing a continuous graph of increase, and can be considered to contain a unit root. However, as can be seen in Figure 2, while the agricultural inflation rate follows an increasing trend over time, the agricultural unemployment rate follows a stagnant course.

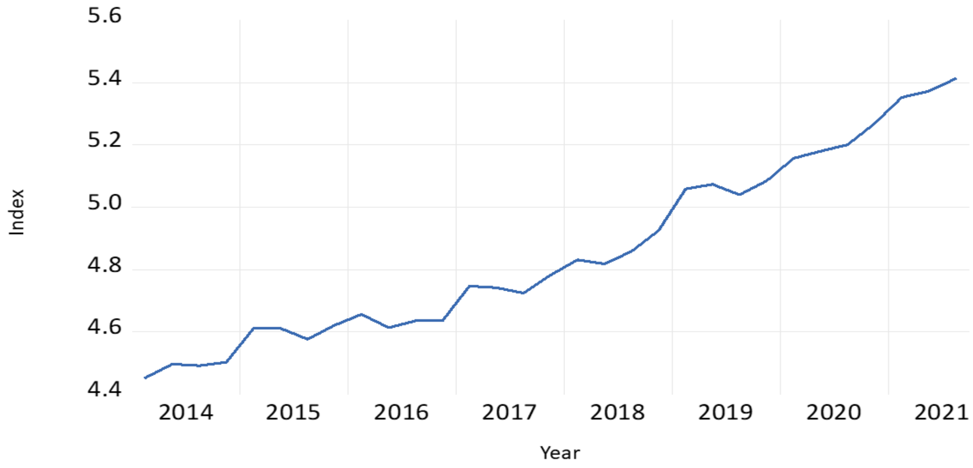

Figure 1- Agricultural Price Index (2014Q1-2021Q3)

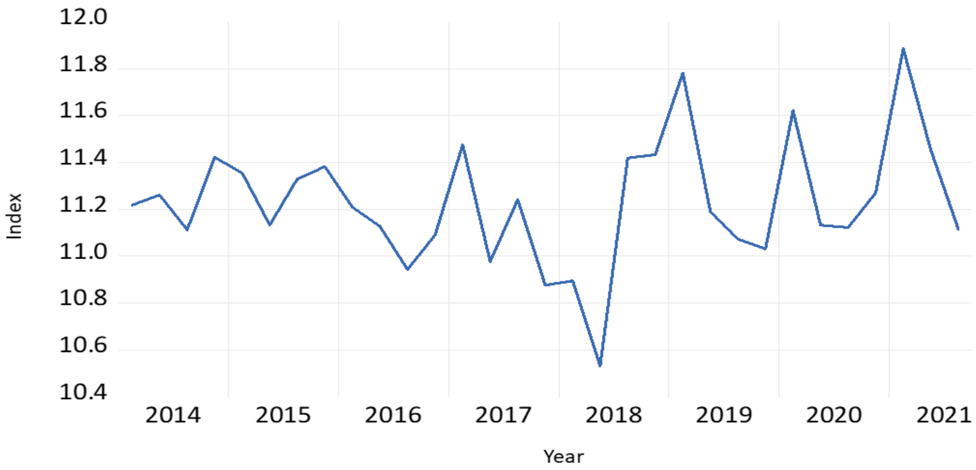

Figure 2- Agricultural Unemployment (2014Q1-2021Q3)

Before analyzing whether the Phillips curve is valid in the agricultural sector, we tested the stationarity of the variables used. Immediately after the test, we estimated the NARDL model.

2.1. Unit root tests and NARDL model

In order to test the stationarity in the study, we applied the augmented Dickey-Fuller (ADF) unit root test developed by Dickey & Fuller (1979, 1981) and the Phillips-Perron (PP) (1988) unit root test. The main difference between the PP and the ADF tests is that the lagged values of the error terms are treated as serially correlated and with heteroscedasticity. Additionally, although lagged values are included in the ADF test to eliminate the autocorrelation, the problem is tried to be solved by modifying the test statistics in the PP test. Finally, we applied the Zivot-Anders unit root test to determine whether there were structural breaks.

The NARDL model is an extended version of the ARDL model developed by Pesaran & Shin (1999) and Pesaran et al. (2001), including asymmetric relationships. The asymmetric cointegration regression developed by Shin et al. (2011) can be represented as follows within the framework of the variables used in this study:

$$loginf_t = \theta_0 + \theta_1 logun_t^+ + \theta_2 logun_t^- + \varepsilon_t \quad (2)$$

In the formulation, θ_i, $logun_t^+$, and $logun_t^-$ represent the long-run coefficient vector and the partial sums of the positive and negative changes in unemployment, respectively. In this model, the decomposition into partial sums is determined as follows:

$$logun_t^+ = \sum_{i=1}^{t} \Delta logun_t^+ = \sum_{i=1}^{t} \max(\Delta logun_i, 0) \quad (3)$$

$$logun_t^- = \sum_{i=1}^{t} \Delta logun_t^- = \sum_{i=1}^{t} \min(\Delta logun_i, 0) \quad (4)$$

When the asymmetric regression shown in Equation 2 is added to the unconstrained error correction model proposed by Pesaran et al. (2001), the NARDL model proposed by Shin et al. (2011) is obtained and shown as follows:

$$\Delta loginf_t = \alpha_0 + \alpha_1 loginf_{t-1} + \alpha_2 logun^+_{t-1} - \alpha_3 logun^-_{t-1} + \sum_{i=1}^{p} \alpha_{4i} \Delta\, loginf_{t-i} + \sum_{i=1}^{q} \alpha_{5i} \Delta\, logun^+_{t-i} + \sum_{i=1}^{m} \alpha_{6i} \Delta\, logun^-_{t-i} + u_t \quad (5)$$

Where; *p*, *q*, and *m* are lag lengths determined according to Akaike information criteria (AIC) or Schwarz information criteria (SIC). The long-term effects (θ_1 and θ_2) of the positive and negative shocks in unemployment, shown in Equation 2, can be calculated as follows with the help of the coefficients obtained from the estimation of Equation 2: $\theta_1 = -\alpha_2/\alpha_1$, $\theta_2 = -\alpha_3/\alpha_1$. The short-term effects of positive changes in unemployment can be represented by$\sum_{i=0}^{q} \alpha_{5i}$, and the short-term effects of negative changes are also obtained through$\sum_{i=0}^{m} \alpha_{6i}$. One of the main advantages of the NARDL model is that it allows estimation of the asymmetrical relationships among variables not only for the long run but also for the short run.

In this study, the following stages were followed chronologically while estimating in the NARDL model. Prelusively, a unit root test was conducted to determine the stationarity of the variables. It is not essential that the variables are stationary at different degrees in the NARDL model as in the ARDL model. However, to estimate the long-term coefficients, the quadratic difference of a variable should not be stationary (Narayan & Narayan, 2004). Secondly, the unconstrained asymmetric error correction model shown in Equation 5 was estimated, and the optimal lag length was determined according to the AIC information criteria. Afterwards, the bound test recommended by Pesaran et al. (2001) and Shin et al. (2011) was applied to determine whether there was a long-term relationship among the variables. While applying the bound test, we placed a zero constraint on the lagged coefficients of the dependent and independent variables ($H_0 = \alpha_1 = \alpha_2 = \alpha_3 = 0$), and the *F* statistic was obtained. If the statistical value obtained from the mentioned result was greater than the critical upper value, then we assumed that there was a long-term relationship among the variables, and the long- and short-term effect coefficients would be calculated accordingly.

3. Results

Two of the traditional unit root tests, ADF and PP, were applied to determine the stationarity of the variables as mentioned. Additionally, the Zivot-Anders structural break unit root test was applied to detect the presence of structural breaks. The outcomes are summarized in Tables 4 and 5.

Table 4- Traditional Unit Root Test Results

	ADF	*PP*
loginf	***2.020***[a]	***2.809***[a]
logun	-4.409[b]	-4.590[b]
Δloginf	-6.099[a]	-5.692[a]
Δlogun	-	-

Notes: *Optimal lag lengths are selected automatically according to SIC in ADF test and Newey-West method in the PP test. Both test statistics were compared with the table values of MacKinnon (1996) at the 5% confidence interval. a represents the test format with a constant term, b the model result with a constant term and trend.*

Table 5- Zivot-Anders Unit Root Test Results

Variables	*Level*		*First Difference*		*Result*
	*Test Stats.**	*Critical Value***	*Test Stats.**	*Critical Value***	
loginf	***-2.24*** (2016Q2)	-4.93	-7.29 (2015Q3)	-4.93	***I(1)***
logun	***-3.35*** (2019Q1)	-4.93	-7.40 (2018Q3)	-4.93	***I(1)***

Notes: * *These are test statistics with fixed terms. Terms in parentheses indicate periods of structural break; **: 5% critical values*

According to the traditional unit root test results, although only the inflation variable was first-order stationary, when structural breaks are taken into account, both variables were found to be stationary in the first order. In terms of level values, the inflation variable showed a structural break in the 2016Q2 period, and the unemployment variable showed a structural break in the 2019Q1 period. Therefore, a dummy variable that took the value of 1 in the mentioned periods and 0 in other periods was added to the model while making the estimation.

After determining the degrees of stationarity, we began the estimation phase of both the ARDL and NARDL models in order to examine the relationships among the variables since there was the probability of finding asymmetrical relationships even if there was no linear relationship among the variables. To that end, first, we determined the optimal lag lengths for both models, and then the models were estimated. While determining the optimal lag length, we considered the smallest AIC value without autocorrelation. In the analysis where the maximum lag length was taken as 4, we determined that the optimal lag number was 3 for the ARDL model and 2 for the NARDL (see Table 6).

Table 6- Optimal Lag Length for ARDL and NARDL Models

	ARDL		*NARDL*	
p	***AIC***	***LM***	***AIC***	***LM***
1	-3.8198	0.1978	-3.8927	0.1034
2	-3.8198	0.1978	**-4.4257**	**0.8926**
3	**-4.0666**	**0.8395**	-4.6234	0.5827
4	-4.0666	0.8395	-5.0599	0.3615

The results of the bound test performed to determine the long-term relationships for linear and asymmetric models are presented in Table 7. As can be seen, in the ARDL model, there was a long-term relationship only at 5% and 10% confidence intervals while the inflation and unemployment variables were cointegrated in all confidence intervals in the NARDL model.

Table 7- Bounds Test Results for ARDL and NARDL Models

Model	***F Stats.***	***Critical Values***					
		1%		***5%***		***10%***	
		I(0)	***I(1)***	***I(0)***	***I(1)***	***I(0)***	***I(1)***
ARDL(3,1,0)	6.2529	6.34	7.52	4.87	5.85	4.19	5.06
NARDL (2,2,2,1)	7.8044	5.17	6.36	4.01	5.07	3.47	4.45

Tables 8 and 9 summarize the estimated ARDL and NARDL models in order to test the validity of the Phillips relationship in the agricultural sector. Before proceeding to estimating the long-term effects, we applied some additional tests to check the suitability of the models. The R^2 values were reasonably high in both models, which implies that the explanatory power of the independent variables was quite significant. Similarly, other fit tests also indicated that the models work smoothly. Moreover, among the tests, the Breusch-Godfrey LM tests inferred no autocorrelation, the ARCH-LM tests identified no heteroscedasticity problem, and the Jarque-Bera test demonstrated residuals normally distributed. Finally, according to the Ramsey RESET test, the setup of the models was correct, and the coefficients were stable.

Table 8- ARDL (3, 1, 0) Model Estimation Results

Variable	***Coefficient***	***Std. Error***	***t-Stats.***	***Prob.***
loginf(-1)	0.575139	0.177499	3.240242	0.0041
loginf(-2)	-0.202853	0.180949	-1.121049	0.2755
loginf(-3)	0.459151	0.148443	3.093112	0.0057
logun	0.061414	0.022331	2.750164	0.0123
logun(-1)	0.035158	0.026992	1.302510	0.2075
dummy	0.061523	0.034866	1.764558	0.0929
constant	-0.323053	0.500008	-0.646096	0.5256
Diagnostic Tests				

R^2: 0.9923

Adj. R^2:0.9896

F-statistic: 368.75

Prob.(F-stat.): 0.00

D-W: 2.092098

Autocorrelation: *Breusch-Godfrey LM*: $\chi_1^2 = 0.196(0.66)$, $\chi_2^2 = 0.176(0.83)$, $\chi_3^2 = 0.265(0.84)$, $\chi_4^2 = 0.202(0.93)$

Heteroskedasticity – *ARCH LM*: $\chi_1^2 = 0.003(0.95)$, $\chi_2^2 = 0.272(0.76)$, $\chi_3^2 = 0.476(0.70)$, $\chi_4^2 = 0.529(0.71)$

Normality: *Skewness*: 0.5577, *Kurtosis*: 3.9644, *Jarque-Bera*: 2.5470 (0.2812)

Stability: *Ramsey-Reset Test*: $\chi_1^2 = 1.6825(0.21)$,

Table 9- NARDL (2, 2, 2, 1) Model Estimation Results

Variable	*Coefficient*	*Std. Error*	*t-Stats.*	*Prob.*
loginf(-1)	-0.065862	0.217058	-0.303429	0.7655
loginf(-2)	-0.352521	0.173446	-2.032447	0.0591
logunpos	0.119845	0.031408	3.815768	0.0015
logunpos(-1)	0.050586	0.031574	1.602144	0.1287
logunpos(-2)	0.209580	0.054548	3.842153	0.0014
logunneg	0.034656	0.042034	0.824474	0.4218
logunneg(-1)	0.174066	0.054952	3.167619	0.0060
logunneg(-2)	-0.101765	0.032343	-3.146449	0.0062
dummy	-0.095660	0.043864	-2.180823	0.0445
dummy(-1)	-0.054759	0.031314	-1.748726	0.0995
constant	6.373053	1.264862	5.038536	0.0001
Diagnostic Tests				
R^2: 0.9959				
Adj. R^2:0.9931				
F-statistic: 359.04				
Prob.(F-stat.): 0.00				
D-W: 1.957708				
Autocorrelation: *Breusch-Godfrey LM*: $\chi_1^2 = 0.162(0.69)$, $\chi_2^2 = 0.114(0.89)$, $\chi_3^2 = 0.531(0.66)$, $\chi_4^2 = 0.577(0.68)$				
Heteroskedasticity – *ARCH LM*: $\chi_1^2 = 0.114(0.73)$, $\chi_2^2 = 0.965(0.39)$, $\chi_3^2 = 0.659(0.58)$, $\chi_4^2 = 0.422(0.79)$				
Normality: *Skewness*: 0.5824, *Kurtosis*: 3.068, *Jarque-Bera*: 1.588 (0.451)				
Stability: *Ramsey-Reset Test*: $\chi_1^2 = 1.735(0.1032)$,				

When the long-term estimation results of the models employed in the study were examined, we noticed quite remarkable findings.

The linear ARDL model results presented in Table 10 showed a long-term relationship among the variables. Because the calculated cointegration was negative and statistically significant, accordingly, the imbalances that will occur in the system disappear in the long term, and the system converges to its long-term values. Although agricultural unemployment has a positive effect on inflation, this effect is not statistically significant.

Table 10- ARDL (3, 1, 0) Model Long-run Estimation Results

Variable	*Coefficient*	*Std. Error*	*t-Stats.*	*Prob.*
logun	0.572909	0.395764	1.447603	0.1632
dummy	0.364985	0.435301	0.838465	0.4117
CointEq(-1)	-0.168563	0.037108	-4.542555	0.0002
*EC = loginf - (0.5729*logun + 0.3650*dummy)*				

In contrast, the coefficients obtained in the NARDL model, whose estimation results are shown in Table 11, were statistically significant. Accordingly, both increases and decreases in agricultural unemployment positively affected the agricultural price inflation rate. However, the greater effect of positive shocks in unemployment provided strong evidence that the traditional Phillips relationship was invalid in the agricultural sector. Thus, an increase of 10% in agricultural unemployment, for example, was reflected in the price inflation rate at a level of approximately 3%. This situation can be evaluated in the context of increases in food prices, especially because of increases in agricultural unemployment and therefore in production. Since the increase in agricultural unemployment might adversely affect agricultural production, this increase would likely result in an increase in food prices. However, a 10% decrease in the unemployment rate caused price inflation to increase by about 1%. In other words, the traditional Phillips relationship is valid only for negative shocks in unemployment in the agricultural sector. In other respects, the statistical significance of the dummy variable showing structural breaks can be considered to indicate that structural breaks in the agricultural sector will affect inflation negatively.

Table 11- NARDL (2, 2, 2, 1) Model Long-run Estimation Results

Variable	*Coefficient*	*Std. Error*	*t-Stats.*	*Prob.*
logunpos	0.267919	0.021264	12.59991	0.0000
logunneg	0.075408	0.038275	1.970174	0.0664
dummy	-0.106050	0.032394	-3.273745	0.0048
CointEq(-1)	-1.418382	0.232957	-6.088598	0.0000
*EC = loginf - (0.2679*logunpos + 0.0754*logunneg -0.1060*dummy*				

Finally, the cointegration coefficient calculated for the NARDL model was negative and statistically significant. Accordingly, the short-term imbalances were eliminated in the long-term, and the system converged to the long-term equilibrium values. Nonetheless, the fact that the coefficient was greater than one indicates that there were significant fluctuations in the convergence of the system to the long-term equilibrium.

4. Conclusions

There are close similarities between the macroeconomic target sizes of almost all countries throughout the world, regardless of their level of development. For instance, economic growth, external balance, price inflation, and unemployment are used as indicators in the magic diamond approach used by the Organization for Economic Co-operation and Development (OECD) to evaluate the macroeconomic performance of countries. The Phillips curve directly analyzes the relationship between two of these basic quantities. Therefore, the validity of the curve plays a vital role in determining the applicable economic policies. Also, understanding the relationship suggested by the curve has an even more important role for economic politics, especially in countries such as Türkiye, which have shifted from an agriculture base to an industrial base over time and whose population engaged in agriculture has decreased despite the general population increase even though the share of employment in agriculture is still undeniably high. In addition, evaluation of the validity of the curve—which was damaged theoretically by the oil crises, by the Monetarist claim of its short-term validity, and by the New Classicists' rejection of the theory but which re-emerged with the contribution of Lucas to rational expectations—for a sector offers a significant opportunity for researchers in terms of identifying which economic school's approach is most valid today.

In this study carried out in light of these insights, we investigated the validity of the Phillips curve in the agricultural sector in Türkiye and the short- and long-term linear and non-linear relationships caused by positive and negative shocks on unemployment-inflation. Our investigation used the ARDL and NARDL approaches using quarterly data from the first quarter of 2014 through the third quarter of 2021. First, the long-term relationship among the variables was questioned, and we determined that since the null hypothesis was strongly rejected in both models, the variables were related in the long run. Afterwards, we tested for the long-term effects of the explanatory variable in both models. ARDL test findings provided an expected result since, as Phillips (1958:299) claimed, import products in the agricultural sector, synthetic price increases, and wage increases due to cost increases were intense in countries such as Türkiye and showed the validity of the theory. The fact that this result has not been examined in other field studies on this subject is one of the contributions of this study to the literature. Also, although the long-term effects were found to be insignificant in the linear model, we note that the asymmetric shocks that occurred were significant in the long-term.

Furthermore, we determined that price inflation rates had a serious breakdown in the second quarter of 2016, and unemployment displayed similar diffraction in the first quarter of 2019. In fact, when analyzed in terms of price inflation, this was a period in which double-digit figures were reached again in the relevant years. In addition, the unemployment figures in 2019 (after 2009) reached the highest levels since the 1990s. Overall, the findings of the analysis indicated that a 10% rise in agricultural unemployment raised price inflation by about 3% while a 10% decrease in agricultural unemployment raised price inflation by approximately 1% (0.75%). In other words, while the nexus was valid for negative shocks, it was not valid for positive shocks. In terms of these findings, a different result was determined by the studies of Şengönül & Tekgün (2021), Ozan & Bakırtaş (2021), Hepsağ (2009), and Alper (2017), all of which were conducted via the ARDL method. However, similar results were reached in the short term by the NARDL method by Kuştepeli (2005), Önder (2006), Salman & Uysal (2019), and Kayacan & Birecikli (2020). In terms of linear results, our findings are consistent with the results of Geary & Jones (1975), Miroljub (1989), Mawejje & Lwanga(2015), and Sasongko & Huruta (2019) for Ireland, Yugoslavia, Uganda, and Indonesia, respectively. This study, which is one of the few studies related to the agricultural sector in Türkiye, differs from all other field studies in terms of significance and validity of negative shocks in the long term.

Although the agricultural sector is still an important economic sector in Türkiye, it is gradually losing its power, and citizens seem to prefer to produce in different sectors. Therefore, in order to analyze the employment in this sector, it is necessary to analyze the changes in the general level of prices. Shocks that cause the labor market to fluctuate and the asymmetric relationship between vacant jobs and unemployment include factors that increase labor supply and/or decrease labor demand. Although the changes in the economy cause fluctuations in production with shocks, these changes occur via the effect of negative shocks and cause asymmetric effects. Some of the factors that emerge with the asymmetric effects are labor prices and sectoral-capacity utilization. Labor prices become a policy tool used by governments in inflationary or deflationary regimes. As capacity utilization in the economy increases—that is, moves closer to full employment—the economy becomes stronger. In this study, we detected that there was an asymmetrical trend in unemployment rates due to inflationary-deflationary periods in the economy. Moreover, we noted that inflation increased in the long run regardless of the increase or decrease in agricultural unemployment. These findings point to the existence of other structural problems besides unemployment, which should be carefully investigated in the agricultural sector in Türkiye.

Additionally, although according to TURKSTAT data 30% of Türkiye's population lived in villages or towns, that hosted agricultural workforces, in 2007, this rate dropped dramatically to 7% by 2021. Also, elderly rate which is the dependent population aged 65 and over in the rural area was 9% in 2007 but 19% in 2021. Undoubtedly, one of the main reasons behind the increase in the elderly population and the departure of the working population from the region is unemployment caused by the decrease in profit margins in the agricultural sector.

The proof of the validity of the curve indicates that it would be more appropriate for policies in the agricultural sector to apply new-Keynesian recommendations. The accurate analysis of the relationship between price inflation and unemployment and the determination of policies suitable for the sector will also be instrumental in the development of the agricultural sector and its higher contribution to the national product.

The limitation of this study is that it excludes the dependent population from the evaluation. In this regard, we think that it will be an opportunity to consider the dependent population data for Türkiye, in case TURKSTAT publishes it, in terms of developing the Phillips curve in future studies. In addition, we believe that this study will shed light on the deeper economic insights to be made based on the determination of the validity of the Phillips curve.

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