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Examining the Nexus between Inflation and Unemployment (NAIRU Estimation) in Iran

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Abstract

This paper aims to estimate Iran's time-varying Non-Accelerating Inflation Rate of Unemployment (NAIRU) over the period 1986–2018. The NAIRU is estimated step by step starting with the constant NAIRU and then the time-varying NAIRU. The time-varying NAIRU is estimated by the Kalman filter and is compared to HP filter estimates. This model relies on the standard "triangle model" approach that includes various measures of supply and demand shocks in the specification of the Phillips curve. Results show that the NAIRU has been raised during the period, and according to the econometric results, there is a structural unemployment gap in the long-run, and the actual unemployment rate is approaching full employment. In other words, there is not any significant gap between the actual unemployment rate and the estimated one (NAIRU). It shows that the high rate of unemployment is related to the structural elements and cannot be reduced by exerting monetary policies in long run. However, what these policies do in short term is reduce the unemployment rate temporarily and in long run is increasing inflation.

Keywords: Augmented-Expectations Phillips Curve, Inflation, Kalman Filter, NAIRU, Supply Shock, Unemployment.
JEL Classification: C13, C22, E24, E31.

1. Introduction

The concept of NAIRU summarized the observed negative correlation between the unemployment rate and the inflation rate. This correlation persuaded some analysts of the impossibility for governments to simultaneously target both low unemployment and price stability. Therefore, it was the government's job to seek a point on the trade-off

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between the two objectives which matched a domestic social consensus. The measurement of the NAIRU is controversial. "By its nature, it is non-observable, and depends on a wide range of institutional and economic factors. It can only be estimated with uncertainty, and it may well vary over time" (Turner et al., 2001).

NAIRU is a structural indicator and characterized by unemployment persistence. For Iran's economy, it is interesting to assess it for several reasons. The main reason is that Iran's economy has been suffering a relatively high unemployment rate and structural unemployment is an integral part of that. The potential use of this indicator is to provide information about the level of unemployment at which inflation remains stable and it is useful to policymaking. The main hypothesis of the paper is that by estimating a structural indicator such as a NAIRU, policymakers can gain useful insight into the fundamental change of Iran's economy.

The remainder of this paper is organized as follows. Section 2 reviews the theoretical framework of NAIRU. Section 3 summarizes the literature of historical development of the NAIRU concept and reviews the studies related to the Iranian economy. Section 4 estimates the techniques starting with the Phillips Curve and constant NAIRU till the time-varying NAIRU. In Section 5, the model is presented that is adjusted to the case of Iran. Section 6 describes the results of econometric analysis and econometrical interpretation, and finally, Section 7 concludes the paper.

2. Basic Concepts

The positive unemployment gap indicates that the economy does not utilize full potential (Richardson et al., 2000). It has excess labor resources that may lose their skills if not employed over long periods. Whereas the negative unemployment gap shows the inefficiency of the economy as people without required skills are hired (due to a lack of labor force), and employees are overpaid (the wage growth is not dependent on productivity growth) (Richardson et al., 2000). Shortly, the negative unemployment gap causes high inflation and a decline in productivity. It is also one of the causes of overheating[1]. To reach

1. Overheating is a state of an economy when its productive capacity cannot meet aggregate demand (aggregate supply < aggregate demand = excess demand) (Economist, 2007).

long-run stability, the economy has to adjust its unemployment towards its NAIRU. The estimate of the NAIRU would be an appropriate objective, and the considered economic policies should stick to this estimation. The time-varying NAIRU is also an appropriate tool to evaluate the impact of structural changes on the natural rate of unemployment. Policymakers are advised to reduce the NAIRU rather than affect the actual unemployment rates. Also, pursuing expansionary or contractionary monetary or fiscal policies to a large extent is dependent upon whether the actual unemployment rate (U) is below or above the NAIRU.

3. Literature Review

3.1 Development of the NAIRU Concept and Estimation

The relationship between inflation and unemployment has been a major object of macroeconomic analysis, resulting in intense academic activity during the last decades. Phillip (1958) documented an empirical link between the growth rate of wages and the unemployment level. Samuelson and Solow (1960) deduced a trade-off between inflation and unemployment that was refuted later by Phelps (1967) and Friedman (1968). According to Friedman, there is an inflation-unemployment tradeoff in the short-run. If the initial unemployment rate falls below the natural rate of unemployment (full employment), there is an associated increase in the inflation rate due to an increase in labor costs. Lucas is the next protagonist in the story of the natural rate of unemployment, whose research in the late 1960s and early 1970s was responsible for full recognition of the concept in the economic literature. Yet, the debate is still going on. Recently this concept is an important challenge the policymakers face because it is important to identify the rate of capacity utilization that is sustainable in the sense that it is associated with reasonably stable inflation, over the medium to longer-term.

3.2 Previous Studies of the NAIRU of Iran

There has been a growing interest in estimating the NAIRU for the Iranian economy. Table I summarizes some of these studies which differ in sample frequency, size, and the econometric method. While the minimum value of the NAIRU varies from 2% (Golmoradi and

Dezhpasand, 2011) to 7% (Barkchian and Sarem, 2011), its upper limit has shown equally a wide range varying from 14% (Barkchian and Sarem, 2011) to 20.6% (Mottaghi, 1998).

Table1: The Previous Time-varying Estimates of Iran's NAIRU in the Literature

sources	samples	Estimated method	Min		Max		Average NAIRU
			NAIRU	Year	NAIRU	Year	
Abasinejad and Mottaghi (1998)	1959–1996	Kalman Filter	3.5	1971	20.6	1995	8.6
Afshari et al. (2009)	1961–2007	VAR method	4.7	2000	17.4	1988	11.8
Abasinejad and Goodarzi (2011)	1961–2010	Kalman and HP Filter	6.4	2000	16.7	1988	12.3
Barkchian and Sarem (2011)	1990–2009	Ball and Mankiw (2002)	7	1997	16	1990	12
		Bayesian	5	1997	14	2002	11
Golmoradi and Dezhpasand (2011)	1964–2009	SVAR method	2	1976	14.9	2000	9.5
Valadkhani (2013)	1962–2008	Kalman Filter	4.4	1962	11	2008	9
			5.1	1963	11.1	2008	9.3

4. Structure and Methodology of Research

The primary purpose of this paper is to estimate the NAIRU of Iran over the period 1986–2018. To be more specific, this paper has the following objectives:

Firstly, the paper will adjust multiple indicators – the common cycle model to the case of Iran by choosing the best fit of dependent and independent variables, number of lags, and model specifications. Secondly, the model will be explored in two steps: estimation of constant NAIRU and estimation of time-varying NAIRU. Finally, results will be interpreted and political implementation of the NAIRU will be discussed to solve current macroeconomic problems of Iran's concern to inflation and labor market.

Most economists do not use the Phillips curve in its original form because it was shown to be too simplistic. There are two modified forms of the Phillips curve to distinguish between short-run and long-run effects on employment. In the short-run, a trade-off exists between

inflation and unemployment. This relationship is called the expectations-augmented Phillips Curve since it shifts up when inflationary expectations rise. In the long-run, the unemployment rate depends essentially on the structural variables, whereas inflation is a monetary phenomenon. Therefore, the monetary policy cannot affect its "natural rate", also called the Non-Accelerating Inflation Rate of Unemployment (NAIRU), or the employment rate consistent with stable inflation. Gordon (1997) specified a model called the "triangle model" where the inflation is determined by three factors: expectations/inertia, and the pressure of demand as represented by unemployment and supply factors. The following sections explain the framework and the model that describes the NAIRU.

4.1 Theoretical Framework

The concept of NAIRU is difficult to quantify because it is not observable. However, numerous estimation methods can be used to measure this variable. These methods may be divided into three categories: the structural method, the statistical method, and the reduced-form method. In the structural method, the NAIRU is derived as the equilibrium of a structural model of the aggregate wage and price-setting behaviors, assuming that markets are in full or some partial equilibrium. In the statistical method, the actual unemployment rate is directly divided into cyclical and trend components, where the NAIRU is simply the trend component. In the reduced-form method, the NAIRU is estimated, similarly to the structural method, based on a behavioral equation explaining inflation, normally the expectations-augmented Phillips curve. This method is considered as a compromise between structural and statistical methods, and the most popular technique in recent studies because it is simple to apply.

4.2The Model and the Variables

As mentioned in the previous section, first the constant NAIRU model will be identified according to the Gordon model concept, and then the time-varying NAIRU will be described.

Constant NAIRU: The simplest and most basic concept is a constant NAIRU that was said to be true in the 1960s when

economists believed that over the long-run, unemployment converges to its natural rate of unemployment, and is a constant figure. Following Staiger et al. (1996), a benchmark model of the augmented-expectations Phillips Curve is exploited to reach a target. It says that the inflation change is "implicitly driven by the unemployment gap and supply shock" (Staiger et al., 1996).

$$\pi_t - \pi_t^e = \beta(u_{t-1} - \bar{u}) + \gamma X_t + v_t \quad (1)$$

Where u_t is the unemployment rate, π_t is the inflation rate, π_t^e is the expected inflation, $\bar{u}$ is the NAIRU, X_t is the supply shock variable, and v_t is the error term. The empirical implications require an estimate for the expected inflation. One approach is that to have expectations are adaptive. Previous studies by Gordon (1990), Weiner (1993), and Eisner (1995) stick to that inflationary expectations. Regarding the hypothesis, the model can be defined as below:

$$\Delta\pi_t = \beta(u_{t-1} - \bar{u}) + \gamma X_t + v_t \quad (2)$$

To address the inaccuracy of the NAIRU estimate, the lagged effects of the unemployment, inflation, and the supply shock are added to deal with the serial correlation in the error term,

$$\Delta\pi_t = \beta(L)(u_{t-1} - \bar{u}) + \delta(L)\Delta\pi_{t-1} + \gamma(L)X_t + \varepsilon_t \quad (3)$$

where L is a lag operator. Despite an unobserved variable $\bar{u}$, the equation is run via OLS.

Time-Varying NAIRU: In this section, we present briefly the model of the time-varying NAIRU relying on the standard "triangle model" approach that includes various measures of supply and demand shocks in the specification of the Phillips curve (Gordon, 1997).

$$\Delta\pi_t = \beta(L)(u_{t-1} - u_{t-1}^N) + \delta(L)\Delta\pi_{t-1} + \gamma(L)X_t + \varepsilon_t \quad (4)$$
$$\varepsilon_t \sim N(0.\sigma_t)$$

The dependent variable π_t indicates the rate of inflation. The

variable π_{t-1} describes the level of inflation inertia in the economy. The U-U^N is assumed to measure the degree of demand pressures, called the unemployment gap (U and U^N present the unemployment rate and the NAIRU, respectively). The variable X_t measures the degree of supply pressures, and ε_t is the error term. If the sum of coefficient *a(L)* equals unity, then there is a steady-state: the inflation rate remains constant with the unemployment rate at NAIRU ((U_t-U_t^N)=0) and with supply shocks absent (Z_t=0).

The estimation of the TV-NAIRU combines the above-inflation Equation 4 with a second below equation that explicitly allows the NAIRU to vary with time:

$$NAIRU_t = NAIRU_{t-1} + \varepsilon_t^n \qquad (5)$$
$$\varepsilon_t^n \sim N(0.\sigma_t^n)$$

This equation shows that the TV-NAIRU is "assumed to follow an unobserved stochastic process, with the usual pre-specification of its path ranging from autoregressive to random walk or random walk with drift" (Botrić, 2012). The model, including Equations 4 and 5, is a "standard stochastic time-varying parameter regression model that can be estimated using maximum likelihood methods described by Hamilton (1994)" (Gordon, 1997).

The Kalman filter is a widely used method that combines prediction and smoothing of the realized values, removing the effect of the noise, and getting a good estimate of the prediction target (Sorensen, 2005).

We propose the following augmented Phillips curves to estimate the unobserved time-variant NAIRU series over the sample period:

$$\begin{aligned}\Delta \ln(p_t) = {} & \gamma_1(u_{t-1} - u^*_{t-1}) + \beta_1 \Delta \ln(DEX_{t.t-1}) + \theta_1 \Delta \ln(Doil_{t.t-1}) \\ & + \alpha_1 \Delta \ln(p_{t-1}) \\ & + \alpha_2 \Delta(gdp\_gap_t) + \alpha_3 \Delta \ln(Dpm_{t.t-1}) + \varepsilon\, t \end{aligned} \qquad (6)$$

$$u_t^* = u_{t-1}^* + w_{1\,t} \qquad (7)$$

where:

p_t is the inflation based on the consumer price index;

u_t^* is the unobserved NAIRU and $u_t - u_t^*$* is the unemployment gap;

Dpm_t is Import price index changes;
DEX_t is Exchange rate index changes;
$Doil_t$ is Oil price index changes
P_{t-1} is inflation with one lag; and
gdp_gap_t is the output gap.
ε_t and $w_{1\,t}$ are error terms

The unemployment gap is an integral part of the Phillips curve. Besides, since the 1970s, the role of inflation expectations has been considered for the Phillips curve literature. However, to customize the model to be compatible with Iran's Economy, a selection of shock variables was included in the initial specification, which is frequently used for NAIRU estimates in other countries. For measuring productivity, the output gap was taken into account. Moreover, since Iran is a high unemployment country, with presumably significant structural unemployment displayed by a huge proportion of long-run unemployment, other variables were included to touch the Hysteresis Effect. Oil price is an inevitable part of oil-dependent economies. The exchange rate plays role in liquidity which directly exerts influence on inflation and lastly, Import price represents the cost of imported goods that are either consumed or applied in the production chain as intermediate and capital goods which should appear in the Phillip equation[1].

The coefficient of the unemployment gap is theoretically expected to be negative, given the inflation-unemployment trade-off. Also, following Ball and Mankiw (2002), in our specification, it is posited that the expected inflation is equal to the last period's inflation.

5. Results and Discussion

Before estimating the NAIRU by the Kalman filter, the presence or absence of a long-run relationship between inflation and the unemployment rate should be examined. The important result is that the Johansen test was not able to identify any cointegration relationship, so it could be concluded that there is no long-run Phillips curve, but we can have a short-run relationship.

1. Gruen et al., 1999

Table 2: Johansen Cointegration Test

Max-Eigen Statistics Critical Value	Trace Statistics Critical Value	Max-Eigen Statistics	Trace Statistics	Eigenvalue	H_1	H_0
19.39	25.87	16.37316	24.4773	0.420606	r<1	r=0
12.52	12.52	8.104144	8.104144	0.236726	r>2	r<1

Source: Research Finding.

5.1 Results of the Econometric Analysis

Constant NAIRU: The estimated Constant NAIRU run via OLS is log 2.4, which shows that the constant NAIRU for the sample period equals 11.28. Figure 1 illustrates the Constant NAIRU, inflation, and unemployment rate.

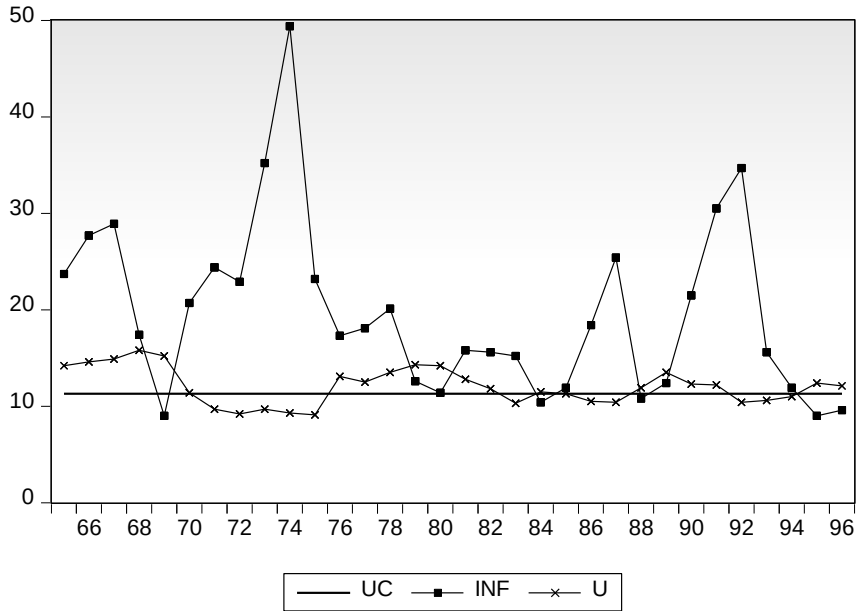

Figure 1: Inflation, Actual Unemployment Rate, and the NAIRU; OLS Based Estimate

Time-Varying NAIRU:

5.1.1 NAIRU using Kalman Filter

For estimating Time-Varying NAIRU by applying Kalman Filter the actual unemployment rate u_t is directly divided into cyclical $u_{p.t}$ and trend components $u_{c.t}$, where the NAIRU is simply the trend component. The result of applying the Kalman Filter for estimating NAIRU is presented in Table 3:

Table 3: Estimating NAIRU Using Kalman Filter Approach

	Coefficient	Std. Error	Z-Statistic	Prob.
u_t	-4.33	0.17	-24.36	0.00
$u_{p.t}$	0.99	0.008	121.05	0.00
	Final State	Root MSE	Z-Statistic	Prob.
$u_{c.t}$	2.49	0.11	21.77	0.00

The probability of the NAIRU estimate is below 0.05, which reflects the relationship between the variables. Figure 2 illustrates the NAIRU obtained through Kalman Filter via the real unemployment rate.

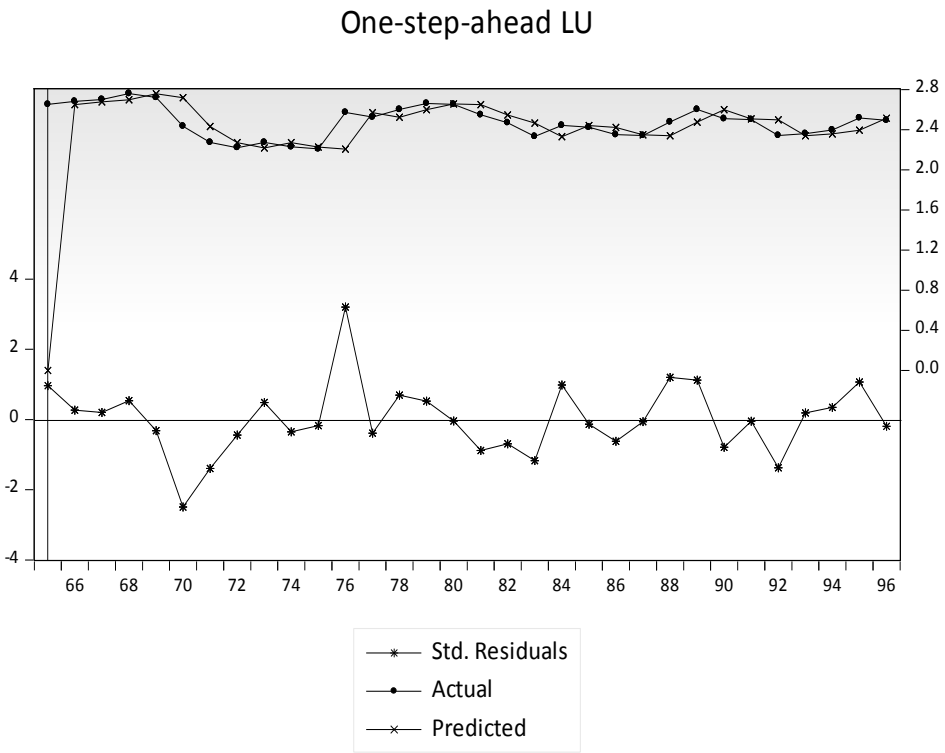

Figure 2: NAIRU Estimated by Kalman Filter Method and Unemployment Rate in Iran, 1366–1396

The first thing to notice is that the Kalman filter estimate of the NAIRU follows the dynamics of the unemployment rate, and strongly follows the underlying series path. It could be concluded that the Kalman filter is a utilized method for estimating the NAIRU in Iran.

Thus, the estimated NAIRU is relatively smooth, which implies that the signal-to-noise ratio is relatively well specified.

5.1.2 NAIRU using HP Filter

Figure 3 shows the estimated NAIRU obtaining by HP filter.

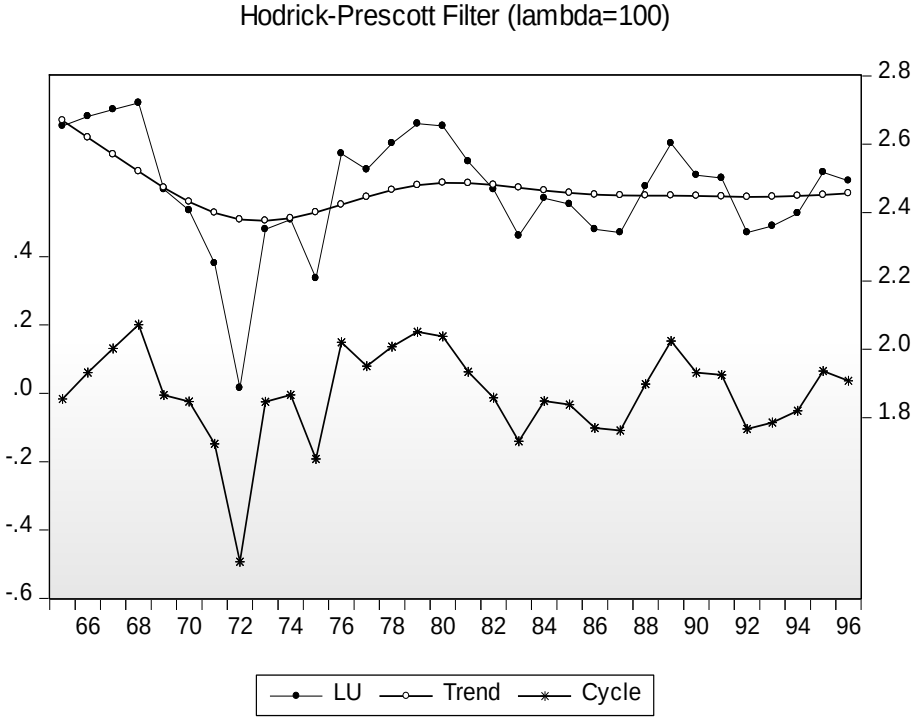

Figure 3: NAIRU Estimated by HP Filter Method and Unemployment Rate in Iran, 1366–1396

By applying this method, the estimated NAIRU is between 11.2% and 15.1% for the relevant period. In the following, we compare the Kalman filter estimates to the HP filter estimates adapting to the Iranian economic situation. After calculating the NAIRU by applying State Space Kalman and HP filter, we investigate the research model that is the modified versions of the Phillips curve augmented by the output gap and import price.

5.2 Estimation of Research Model using State Space System of Equations

Based on the Kalman filter recursive approach, the empirical result of

applying the maximum likelihood estimation method to Equation 6 is presented in Table 4. The estimated coefficients of the Phillips curve are seen to be of consistent sign and orders of magnitude and highly significant at the 0.05% level.

Table 4: The Estimated Model by Employing the Kalman Filter Approach

Prob.	Z-statistics	Coefficient	Variables
0.3247	0.9848	0.0847	Intercept
0.0003	3.5756	0.5421	P_{t-1}
0.0001	-3.8518	-2.0201	$u_{t-1} - u^{*}_{t-1}$
0.0464	1.9915	0.4657	dpm_{t-1}
0.5804	0.5528	0.1062	$Doil_{t}$
0.0384	-2.0709	-0.4244	$Doil_{t-1}$
0.1721	-1.3656	-0.0843	DEX_{t-1}
0.0197	2.3324	0.1681	DEX_{t-2}
0.0438	-2.016	-1.752	gdp_gap_{t}
prob.	**Z-Statistic**	**Final State**	
0.9975	-0.0032	-0.0004	U–GAP
0	-56700.7	-0.0261	U–GAP1
0	256815.9	0.1181	U–GAP2
0	5425176	2.4949	NAIRU
0.5334	-0.6228	-0.0442	GDP–GAP
0	-5.5E+07	-0.0722	GDP–GAP1

Source: Research Finding.

As expected, changes in the import prices exert a positive impact on the inflation rate. Therefore, a 10% change in import prices has led to a rise of approximately 4.6% in the inflation rate. On the other hand, a 1% fall in (U−U*) has resulted in about a 2% increase in the inflation rate. This relatively high coefficient in the model suggests that if the actual unemployment rate is pushed below the NAIRU, a high inflation rate would be unavoidable. The outcome NAIRU in the final state is log 2.49, which is equal to 12.12% and about 0.84%—higher than the constant NAIRU (11.28). According to the results of the model, the rising output gap could also negatively influence the inflation rate.

6. Empirical Results and Policy Implications

In general, statistical and econometric tools should have similar results when treated equally. Results of the estimated NAIRUs by three methods (Constant NAIRU, HP, and Kalman filter) are illustrated in Figure 4. According to Figure 4, the estimated NAIRU by applying the Kalman filter significantly follows the trend of the actual unemployment rate, and the dynamics also reveals that the movements of the estimated NAIRU are relatively smooth. That is the signal-to-noise ratio is relatively well specified. It proves that the Kalman filter is an appropriately utilized method for estimating NAIRU and presents a close estimation of the unemployment rate according to the Iranian economic data.

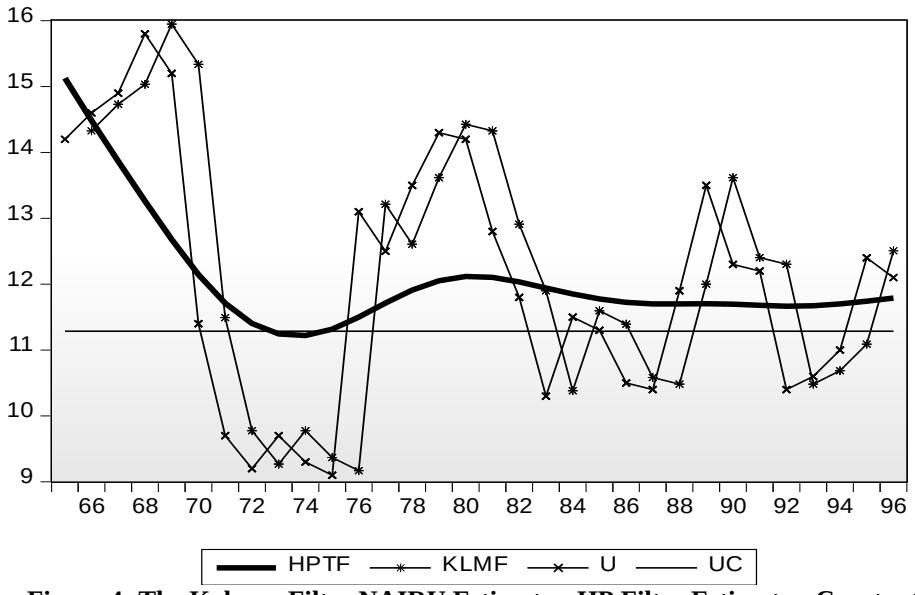

Figure 4: The Kalman Filter NAIRU Estimates, HP Filter Estimates, Constant NAIRU, and Unemployment Rate

The estimated NAIRU approached by applying HP filter fluctuates between 11.2 and 15.12 during the sample period. As it is obvious, the average HP estimated NAIRU is above the actual unemployment rate (11.9) for the whole sample, which is expected to raise the inflationary expectation. Reviewing the inflation growth rate confirms the result.

In the last point for this analysis, we compare the Kalman filter estimates to HP filter estimates. According to previous studies, there are various factors to choose the best method of NAIRU estimation. In

general, the Kalman Filter is before HP, but in some cases, when the NAIRU fluctuations do not follow the actual unemployment rate or for transition countries where suffer from lack or unreliable sources of data, the Kalman filter is not a suitable method for estimating the NAIRU.

6.1 Interpretation of the Model Coefficients

The estimated model based on Final State of Kalman filter NAIRU is presented as below:

$$\Delta ln(p_t) = 0.08 - 2.02(u_{t-1} - u^*_{t-1}) - 0.42\Delta ln(Doil_{t-1}) + 0.11\Delta ln(Doil_t)$$
(0.09)* (0.52) (0.20) (0.19)
[0.98]* [-3.85] [-2.07] [0.55]

$$+0.54\Delta ln(p_{t-1}) + 0.47\,\Delta ln(dpm_{t-1}) - 0.08\,\Delta ln(DEX_{t-1}) \quad (8)$$
(0.15) 0.23) (0.06)
[3.57] [1.99] [-1.36]

$$+0.17\Delta ln(DEX_{t-2}) - 1.75\Delta(gdp\_gap_t)$$
(0.07) (0.87)
[2.33] [-2.02]

* Standard errors are located in parentheses and Z statistics are located in brackets.

The estimated coefficients of the Phillips curve are seen to be of the expected sign. The negative sign of the unemployment gap asserts the presence of a short-run relationship of the Philips curve. Furthermore, the value of coefficients shows that the demand elasticity factors have more influence on inflation than the cost-push factors. In the estimated model, the role of adaptive inflationary expectation is also significant.

With the increase in import prices, the cost of imported goods will rise. So the demand for domestic products increases and the cost of production of industries whose primary resources are supplied from abroad goes upward too. On the other hand, the ratio of export to import price will decrease. The net exports will rise, leading to an increase in aggregate demand and inflation.

The increased oil prices in the short-run will raise the production

and employment rate, and reduce the inflation rate. While in the long-run, the increased liquidity accelerates inflation. On the other hand, with the increased government's oil revenues, net government expenditure will decline, and this, as a contractionary policy, will reduce the total demand and the inflation rate.

6.2 Comparing the Results of Estimated NAIRU with Previous Studies

The estimated NAIRUs in the present study using the Kalman and Hedrick Prescott filter equals 12.15 and 13.16 average respectively. Comparing these values with the previous studies of NAIRU estimations[1], it is obvious that the NAIRU has had an increasing trend which shows the increased structural problems and the increased share of structural unemployment in the economy.

7. Conclusion

This research aimed to find an estimate of the NAIRU for recent decades. We can provide data for the actual unemployment rate, but there is no estimate of the NAIRU because it is an unobservable macroeconomic variable. The estimate was achieved step by step starting with constant-NAIRU and proceeding with time-varying NAIRU. The results show that the actual unemployment rate is close to the natural rate of unemployment, and any other decrease in unemployment using expansion policy will raise the risk of overheating and additional inflation pressure. So if the government attempts to drive unemployment down below the NAIRU, the result will only increase inflation. Based on the above-mentioned reason, it is concluded that government solutions are effective just in the short-run, as they do not deal directly with the labor market. However, more activities should be implemented to make significant changes in the labor market structure.

Unemployment rates in other countries are not nearly as high as in Iran. In other words, comparing this index with its parallels in countries such as Morocco (9.3), United Arab Emirates (2.2), Qatar (0.1), Egypt (9.8), Saudi Arabia (6)[2] to name a few _some countries named in the Twenty-year vision document_ makes it obvious that Iran's

1. See Table 1.
2. https://ilostat.ilo.org/topics/unemployment-and-labour-underutilization/

unemployment rate is considerably high. This reveals the need for fast action to reduce it. In my opinion, as the main proportion of Iran's unemployment rate has structural reasons, the monetary policies cannot reduce this rate without tolerating soaring inflation. Besides, according to the results of the present study, the estimate of NAIRU has been following the trend of the actual unemployment rate and has been increasing over the sample period. Finally, it can be concluded that the main reason of increasing in NAIRU in recent decades has been caused by the "hysteresis effect" and "shadow economy" in the labor market which are irrefutable proofs for structural unemployment.

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