

# EVIDENCE OF ASYMMETRIES AND NONLINEARITY OF UNEMPLOYMENT AND LABOUR FORCE PARTICIPATION RATE IN UKRAINE

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## Abstract

With respect to instability and structural changes for maintaining effective functioning of economy an important issue is to study the dynamics of processes in the labour market, including labour supply and employment. Considering negative demographic trends and an acute problem of population aging in Ukraine the article presents an empirical research of the dynamics of labour force participation and unemployment rate, as well as the correlation relationship between them in various periods of time. On the basis of threshold-disturbance moving average and threshold-disturbance autoregressive models there are elicited significant asymmetric reactions of labour force participation rate, unemployment rate and productivity to positive and negative macroeconomic shocks. For modelling the asymmetric behaviour of economic activity of population there is developed a nonlinear logistic smooth transition autoregressive model. In the result of econometric analysis there is received large estimated value of slope parameter which characterizes the smoothness of transition. This indicates that the economic activity of the population in Ukraine quickly reacts to the previous changes that took place in the labour market. In times of crisis Ukrainian households increase labour supply and show increased activity in job search in order to prevent the decline of their income.

**Keywords:** labour market, unemployment, labour force participation rate, asymmetry, LSTAR model, Ukraine

**JEL Classification:** C30, E24

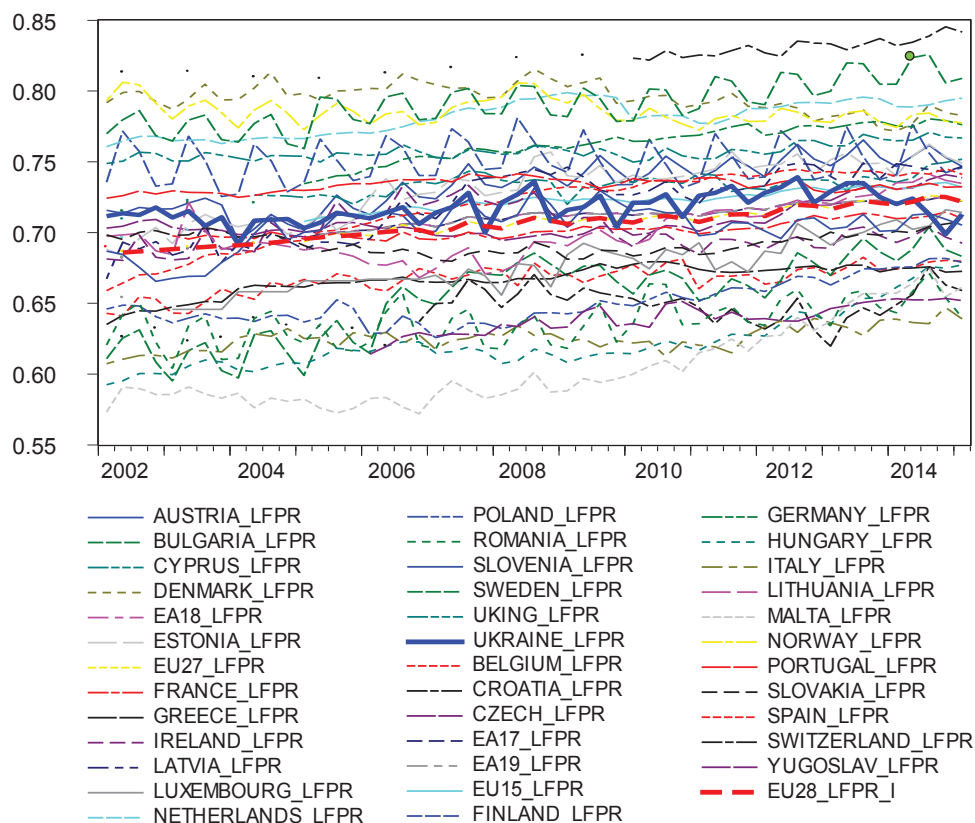
## 1. Introduction

The current state of the labour market in Ukraine is characterized by large disparities which are inherent for transitional and crisis periods of economic development. In particular, such asymmetries as institutional, economic, social and informational ones exist, with both positive and negative consequences. The existing significant discrepancies in the employment structure, wages and labour productivity, increased unemployment, uneven income distribution and social vulnerability of poor people show urgent problems in social and labour spheres that are caused by both internal and external factors.

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**Figure 1 | Dynamics of Labour Force Participant Rate (LFPR) in European Countries during Years 2002–2015**

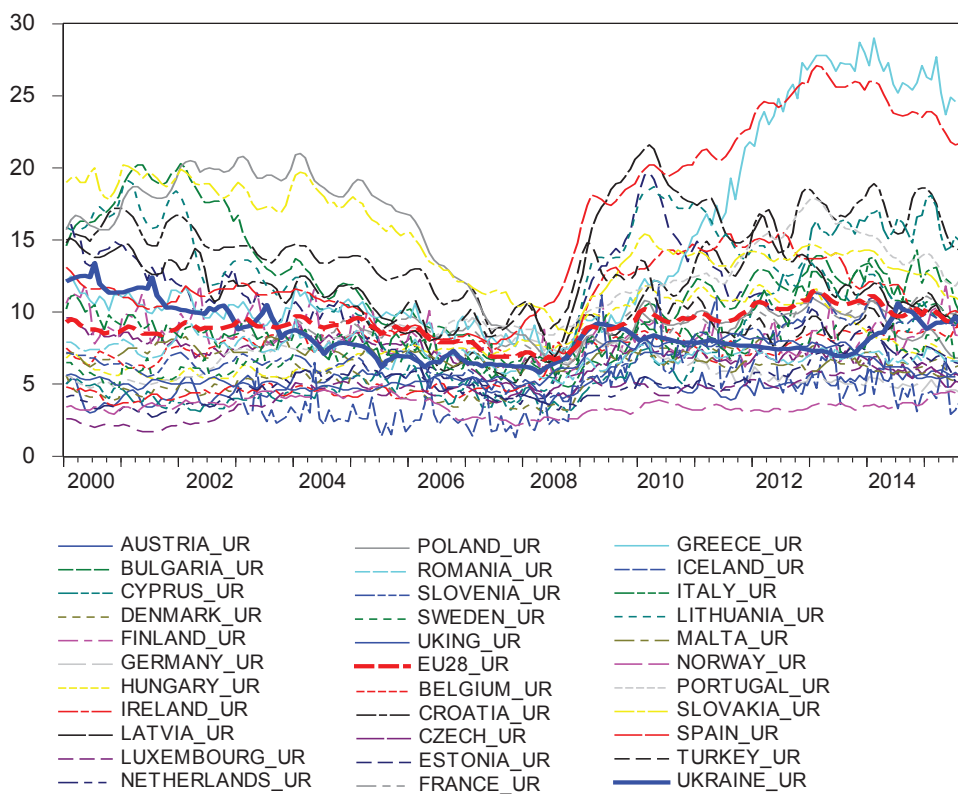


Source: data from EUROSTAT Database and State Statistics Service of Ukraine, elaborations of the author.

Conclusions of the research of labour markets and economic fluctuations in the works of scientists from different countries demonstrate the importance of analysing the dynamics of unemployment rate (UR) and labour force participation rate (LFPR) as for developed countries (D. Petrongolo, C. Pissarides, M. Elsby, B. Hobijn, A. Sahin, W. Zandewghe *et al.*), and for developing countries (O.Yuldashev, O. Khakimov, S. Verick, S. Cengiz, A. Sahin, A. Kolot *et al.*), as well as the correlation relationship between them (D. Dagsvik, T. Kornstad, T. Skjerpen, Y. Ozerkek, E. Papapetrou, D. Bakas *et al.*). Over the last decade Ukraine is characterized by approximately the average European level of economic activity of population and similar dynamic properties with upward trend (Figure 1). However, the dynamics of labour force participation rate demonstrates slightly different trend characteristics if compared to countries where this indicator is close to Ukraine (Estonia, Latvia, Lithuania, Slovenia, Spain). Particularly in Ukraine, economic activity has been increasing considerably slower, especially in the post-crisis period since 2008 and is characterized by a significant decline during

the 2014–2015. Such dynamics is caused by poor economic development and complicated political situation in Ukraine. Dynamics of unemployment rate in contrast to the labour force participation rate is significantly different for various European countries (Figure 2). Ukraine shows its own fluctuations. The unemployment rate in Ukraine has increased significantly since the crisis in 2008, although not as much as in Greece and Spain. Revolution that took place in Ukraine at the beginning of 2014 has led to a rapid increase in unemployment rate and decrease in economic activity of the population, which has not returned due to military action in the East of the country and economic instability.

**Figure 2 | Dynamics of Unemployment Rate (UR) in European Countries during Years 2002–2015**



Source: data from EUROSTAT Database and State Statistics Service of Ukraine, elaborations of the author.

Unemployment rate and economic activity depend on many factors. As well the labour market indicators responded to changes in these factors in various countries differently. Important determinants of the long-term trends in labour supply are the demographic and educational situation. Changes in the age structure of the population have a significant impact on the dynamics of processes in the labour markets of European countries (Biagi and Lucifora, 2008). Research of differences in economic activity and unemployment

rates among European countries demonstrate the importance of age and cohort effects, which determine changes in social norms and preferences for participation in the labour market (Balleer, Gomez-Salvador and Turunen, 2014) and significant long-term dependencies between unemployment rate and macroeconomic variables (GDP and inflation), particularly among young people (Caporale and Gil-Alana, 2014).

Demographic trends in Ukraine are critical. During the last decades because of low birth rate, high mortality rate and emigration of people of working age there occurs a sharp decrease of the population in Ukraine (12.5% in the last 20 years). Moreover, similarly to other European countries there is a significant aging of population. Ukraine is classified as an “old” nation. The proportion of the population whose age is over than 65 years is more than 15%, and the percentage of people aged over 60 years is about 22%.

Migration is also an important demographic factor that influences economic activity and unemployment rate (Tudorache, 2006). In Ukraine there prevails workforce emigration mostly to Poland, the Czech Republic, Italy, Portugal and Russia. However, it is impossible to adequately measure the effect of such labour force leaving because of the lack of truthful data and due to the fact that such labour force flows are usually illegal.

Economic activity and unemployment rate (UR) are different in various regions of Ukraine, while their dynamics depends on specifics of the region. Situation in Ukraine is similar to European countries where using the standard deviation, non-parametric kernel densities and stochastic kernels are determined in two different periods, and they detected strong polarization after the crisis (between 2007 and 2013) which applies to both countries and regions (Beyer and Stemmer, 2016).

Differences in overall economic activity and unemployment rate in various countries are to a certain extent caused by differences in the economic activity of women, which are very different for developed countries (Ukil, 2015; Mishra and Smyth, 2010) and developing countries (Abdullov *et al.*, 2014; Naidu, 2016). In the meantime, the research of the hypothesis that the economic activity of women is characterized by U-curve and depends on the development of country (including structural changes, education, human capital development, dynamics of birth) does not give definitive conclusions and empirical evidence (Gaddis and Klasen, 2014; Tam, 2011). In particular, study of women’s economic activity based on two-step methodology of econometric exercise and general equilibrium modelling indicates the importance of specific barriers in some countries (Tsani *et al.*, 2013). In developing countries significant differences in the economic activity of women are caused by a wide variety of economic and social factors that include economic growth, education, social norms (Verick, 2014). Important factors are also international migration (Abdullov *et al.*, 2014) and historical unforeseen circumstances (Gaddis and Klasen, 2014). In Ukraine these factors have a significant impact. The economic activity of women is significantly lower (about 10–15%) than the economic activity of men, particularly because household duties and responsibilities of caring for the children are laid mainly on women. This situation is encouraged by fairly high social payments after childbirth and is caused by limited access to high-quality services for caring for the children.

Apart from demographic and cyclical factors researchers demonstrate the importance of educational level and social welfare programmes (Kennedy and Hedley, 2003), pay inequality, cohesion and competitiveness (Galbraith and Garcilazo, 2010), state of health of the nation (Cai, 2010), which unfortunately are currently not at a high level in Ukraine.

However, long-term (demographic) trends explain only part of the changes in the labour supply and the rest of the changes are caused by cyclical factors including recession (Zandweghe, 2012). Studies show that economic activity is pro-cyclical in the USA (Erceg and Levin, 2014), while in the euro area it is countercyclical (Nucci and Raggi, 2016). In Ukraine like in other European countries a desire to get additional job and additional income prevails over “pessimistic attitudes” about the possibilities of the labour market. Since nominal wage is not flexible and inflation is high, the real wage decreases. This leads to an increased economic activity due to the effects of habits and consumer preferences which are usually strong (Blanchard, Gali, 2007). In Ukraine as well as in some European developing countries (Yuldashev and Khakimov, 2011; Senaj *et al.*, 2016) economic activity is also sensitive to changes in wages that arise from changes in income taxes and transfers but the elasticity of these changes is small.

During economic fluctuations it is important to study the relationship between economic activity and unemployment rate. Works of a number of scientists show that in European countries changes in labour force participation rate are related to changes in cyclical unemployment (Elsby *et al.*, 2013; Petrongolo and Pissarides, 2008). However, direction and causality of this interrelation and correlation sign can be different and depend on the economic environment. In particular, study of 40 OECD countries reveals that inflow of economic activity of a population is accompanied by increased unemployment rate, while the outflows of potential employees from the labour force and their transition to inactive status with a some lag causes a negative shift in the unemployment rate (Elsby *et al.*, 2013). Meanwhile studies of the labour market in Greece, which has undergone significant disturbances and is characterized by the medium level of economic activity and simultaneously the highest unemployment rate in Europe based on the two-regime threshold cointegration model, show that the LFPR was increasing in the period from 1990 to 2010 demonstrating the long-term trend and was not dependent of UR. However, after 2010 LFPR shows a strong negative dependence on UR, which was high in this period and associated with the fall in employment rate (Papapetrou and Bakas, 2013). Whether a person decides to work or not they evaluate the expected benefits from job search and state of labour market and in the process a significant part of the unemployed becomes discouraged. In particular, in European countries discouraged worker effect is rather high among women indicating the undervaluation of female unemployment (Ozerkek, 2013; Dagsvik, Kornstad and Skjerpen, 2013). At the same time high level of UR not always pushes from seeking job although new members of labour force have little chance for work.

At the present stage of development the Ukrainian labour market is characterized by asymmetry of natural, social and migratory reproduction of population as well as spatial asymmetry of regional labour resources placement (Krasnonosova and Yermolenko,

2013); significant economy dependence on inconsistent political decisions, aging of production assets due to insufficient funding of the production sector (Lukyanenko and Semko, 2012); the limited effect of foreign direct investment and asymmetry in the distribution of productive forces (Maslov, 2012); underutilization of labour resources and not optimal employment allocation (Kolot, 2012); inconsistency between professional and qualification structure of regional labour resources and needs of regional labour markets (Daradkeh *et al.*, 2012). Moreover, the labour market is also characterized by asymmetry in processes of adaptation to the changing market conditions. In this regard, an important issue is the development and analysis of nonlinear economic and mathematical models, which allow to identify the characteristics of asymmetric dynamics of the main macroeconomic indicators of the labour market and their reactions to positive and negative shocks that disturb the economic environment.

Analysis and study of asymmetric and nonlinear behaviour of labour market indicators for different countries are based on an investigation of econometric time series models (Acemoglu and Scott, 1994). In particular, Faria, Cuestas and Mourelle (2010) substantiated the causality direction and nonlinearity of the relation between unemployment and entrepreneurship and estimated STAR-EXT model for a set of OECD countries. Holmes and Silverstone (2006) used a nonlinear Markov regime-switching approach for modelling an asymmetry between unemployment and output in the United States in 1991 and 2001. Pérez, Rodríguez and Usabiaga (2003) detected a nonlinear and asymmetric nature of relationship between the output gap and the unemployment gap for Andalusia and Spain. Cancelo (2007) investigated the nonlinearities in the unemployment rates of six developed economies by using a smooth transition autoregression model where the transition variable is GDP growth, and he indicated that nonlinearities are induced by cyclical asymmetries. Hotchkiss and Robertson (2012) by using the standard labour-leisure choice model found that labour force participation decisions across demographic groups in response to changes in labour market conditions are asymmetric. Cengiz and Sahin (2014) evaluated smooth autoregressive transition models for Turkish labour force participation rates and showed a nonlinearity of behaviour of participation rates for men and women.

For Ukraine such research of the dynamics of economic activity and unemployment rate features and correlative connection between them has not been done and they are the subject of this article. Considering the significant turmoil, in which Ukraine has been embroiled, its experience is an interesting example of possible relationships in the labour market related to the dynamics of economic activity and unemployment rate in terms of structural changes and strong disturbances as well as effect of impact of different signs shocks.

## **2. Data and Empirical Analysis**

We conduct an empirical analysis and econometric modelling of behaviour of the key labour market indicators to identify the characteristics of their asymmetric dynamics, to improve the correctness of their forecasts and the effectiveness of conducting social and

economic policies measures in conditions of economic instability in Ukraine. Statistical research will be performed on a basis of a quarterly data for years 2002–2015 obtained from statistical reports of the Ukrainian State Statistics. Namely, we will examine series: *UR* (unemployment rate determined by the ILO in %); *UROF* (registered unemployment rate in %);  $RR = 100 * UROF/UR$  (the percentage of the unemployed registered in employment centres); *LFPR* (labour force participation rate among population aged 15–70 years in %); *EMPL* (employed population in thousands persons); *PROD* (productivity in thousands of UAH per person); *UNEMPL* (number of unemployed population in thousands of persons); *UNEMPLOF* (number of officially registered unemployed persons in thousands of persons). In Table 1 there are some of their statistical characteristics.

**Table 1 | Statistical Characteristics of Population Unemployment and Economic Activity Indicators**

Period	Mean	Minimum	Maximum	Standard Deviation
<b>Unemployment rate (<i>UR</i>)</b>				
<b>2002–2004</b>	9.12	6.08	11.23	1.29
<b>2005–2008</b>	6.69	5.21	8.71	1.16
<b>2009–2013</b>	7.91	6.17	9.48	0.92
<b>2014–2015</b>	9.35	8.16	10.59	0.89
<b>Registered unemployment rate (<i>UROF</i>)</b>				
<b>2002–2004</b>	3.70	3.40	4.00	0.15
<b>2005–2008</b>	3.08	2.40	3.90	0.39
<b>2009–2013</b>	2.56	1.80	4.40	0.62
<b>2014–2015</b>	2.52	2.20	3.00	0.30
<b>Percentage of the unemployed registered in employment centres (<i>UROF/UR</i>)</b>				
<b>2002–2004</b>	41.27	32.93	55.88	5.81
<b>2005–2008</b>	46.67	37.17	60.28	6.29
<b>2009–2013</b>	32.29	25.41	46.38	5.91
<b>2014–2015</b>	27.11	22.66	31.16	3.87
<b>Labour force participation rate (<i>LFPR</i>)</b>				
<b>2002–2004</b>	62.58	60.10	63.04	0.79
<b>2005–2008</b>	62.54	61.20	64.70	0.98
<b>2009–2013</b>	64.18	62.10	65.70	0.92
<b>2014–2015</b>	62.32	60.60	63.40	1.12

Source: data of the State Statistics Service of Ukraine, calculations of the authors.



Analysis of economic activity and unemployment rate as well as research of relationship between them during the different periods of business cycle were a point of interest for many scientists all over the world. In particular, Kakinaka and Miyamoto (2012) estimated long-term cointegration relationships between LFPR and unemployment rate in Japan and they demonstrated that LFPR series can decrease because of discouraged worker effect during the periods of unemployment rate rising. Liu (2014) complemented the research for Japanese economy considering the possibility of multiple structural breaks for panel data from a regional perspective. Emerson (2011) was modelling interrelation between the labour force participation rate and UR for the USA historical data. Scientists state that high unemployment rate during recession can force people to refuse from job searching, because in such periods job searching costs may prevail over an employment benefits (Benati, 2001). As a result, a negative correlation between unemployment and economic activity can be observed, and therefore the unemployment rate may be a significant factor that negatively affects the decision of entering a labour force or not. However, other research (Hernández and Orraca, 2009) shows that at the same time (during economic recessions) households increase their job offer to prevent reduction of their income, and young workers demonstrate significant activity in job searching. In this regard, rise in unemployment may be accompanied by an increase in LFPR during the business cycles, and in the long-term prospect a relationship between the LFPR and unemployment may not be traced.

In Ukraine, instability of the labour market caused by the instable development of national economy and its separate sectors, as well as typical seasonal fluctuations obstruct ensuring stable employment of working population. Conducted statistical analysis shows that a significant negative correlation for the entire period from 2002 to 2015 exists between unemployment rate and coefficient of labour force participation (Table 2). Also after 2009 inverse relationship between *UR* and *LFPR* strengthened. If until 2008 the correlation factor had been about  $-0.5$ , then after 2009 it was almost  $-0.9$  indicating that over time in Ukraine the increased unemployment is accompanied by a significant reduction of the labour force participation factor.

**Table 2 | The Correlation Coefficients among Labour Force Participation Rate, Unemployment Rate Defined by ILO and Registered Unemployment Rate**

Period	Corr [ <i>LFPR</i> , <i>UR</i> ]	Corr [ <i>LFPR</i> , <i>UROF</i> ]	Corr [ <i>UR</i> , <i>UROF</i> ]
<b>2002Q1–2008Q4</b>	–0.4819 ( <i>p</i> -value = 0.0094)	–0.4367 ( <i>p</i> -value = 0.0201)	0.7847 ( <i>p</i> -value = 0.0000)
<b>2009Q1–2013Q4</b>	–0.8690 ( <i>p</i> -value = 0.0000)	–0.3195 ( <i>p</i> -value = 0.1697)	0.6062 ( <i>p</i> -value = 0.0046)
<b>2014Q1–2015Q4</b>	–0.9624 ( <i>p</i> -value = 0.0087)	–0.0236 ( <i>p</i> -value = 0.9700)	0.0564 ( <i>p</i> -value = 0.9282)

Source: elaborations of the authors.



The similar result is obtained by exploring the dynamic correlation based on estimating the distributed lag model

$$LFPR_t = \alpha_0 + \alpha_1 UR_t + \alpha_2 UR_{t-1} + \alpha_3 UR_{t-2} + \varepsilon_t$$

on the basis of samples for different periods (Table 3).

**Table 3 | The Dynamic Correlation Coefficients among Labour Force Participation Rate and Unemployment Rate**

Period	$\alpha_1$	$\alpha_2$	$\alpha_3$
<b>2002Q1–2008Q4</b>	−0.3413 ( <i>p</i> -value = 0.0082)	−0.0463 ( <i>p</i> -value = 0.7387)	0.2025 ( <i>p</i> -value = 0.0958)
<b>2009Q1–2013Q4</b>	−1.1643 ( <i>p</i> -value = 0.0000)	0.4050 ( <i>p</i> -value = 0.0002)	−0.3987 ( <i>p</i> -value = 0.0002)
<b>2014Q1–2015Q4</b>	−1.0764 ( <i>p</i> -value = 0.0016)	−0.1411 ( <i>p</i> -value = 0.3832)	−0.0533 ( <i>p</i> -value = 0.6023)

Source: elaborations of the authors.

At the same time, conducting a comparative statistical analysis of seasonal series properties of *LFPR* and *UR*, we find out that the unemployment rate shows seasonal fluctuations opposite to those revealed by economic activity coefficient. In particular, in the second and third quarter, the unemployment rate is relatively high, and on the contrary the economic activity of the population is low (Figure 3), which may be caused by the anticipation of bad prospects for employment and the discouraged effect of individual employees in the short term.

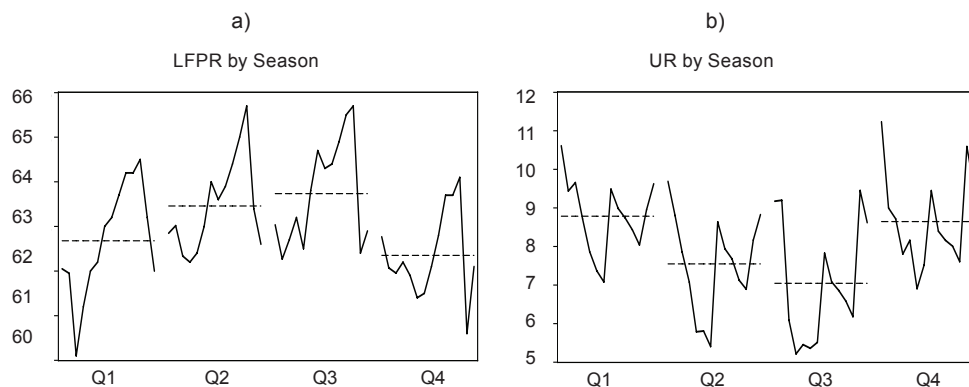
Deepening the analysis and examining the correlation among seasonally adjusted series, that is series, from which seasonal factors were eliminated using the moving average methods, we get opposite conclusions and positive correlation coefficient (Figure 4b).

Therefore, it can be confirmed that a seasonal rise in unemployment causes a short-term reduction in the coefficient of labour force participation, while in the long term Ukrainian households show increased economic activity and growth in the rate of entry into the labour force in response to an increase in the unemployment rate and the corresponding reduction of their income.

In Ukraine besides the unemployment rate which is determined by the International Labour Organization also the registered unemployment rate (*UROF*) is calculated. According to current legislation registered unemployed are people of working age who are registered in the local public employment services in Ukraine and receive unemployment benefits. Since the social assistance to the unemployed in Ukraine is low, and moreover the procedure to obtain it for many unemployed is difficult, many people do not register as unemployed in the labour market, so the registered unemployment rate

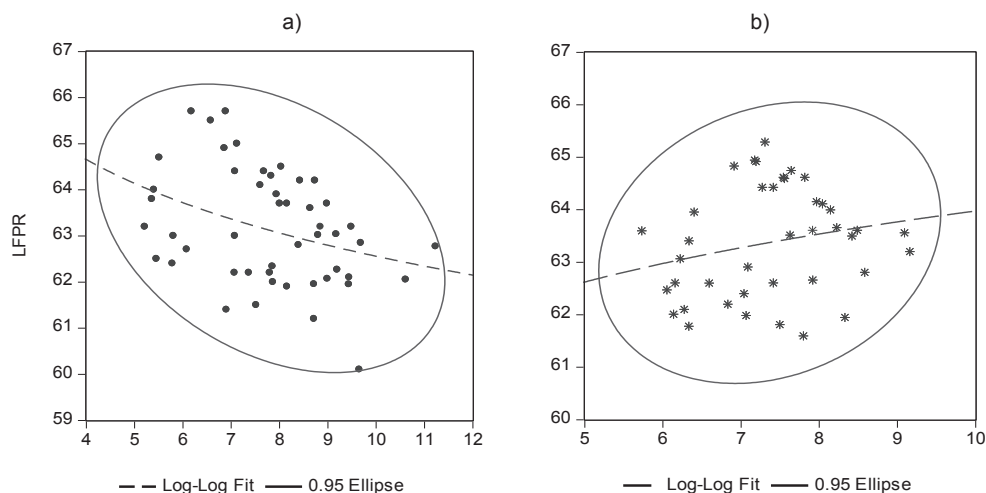
(*UROF*) is significantly lower than the unemployment rate defined by ILO (*UR*) (Table 1). Analysis of the ratio of *UROF* and *UR* enables to estimate the effectiveness of public policy on preventing mass unemployment and to some extent the degree of people confidence in the state on the issue of employment, compulsory state social insurance against unemployment especially at the regional level.

**Figure 3 | The Seasonal Behaviour of the Labour Force Participation Rate and Unemployment Rate**



Source: data of the State Statistics Service of Ukraine, elaborations of the authors.

**Figure 4 | The Correlation between LFPR and UR**

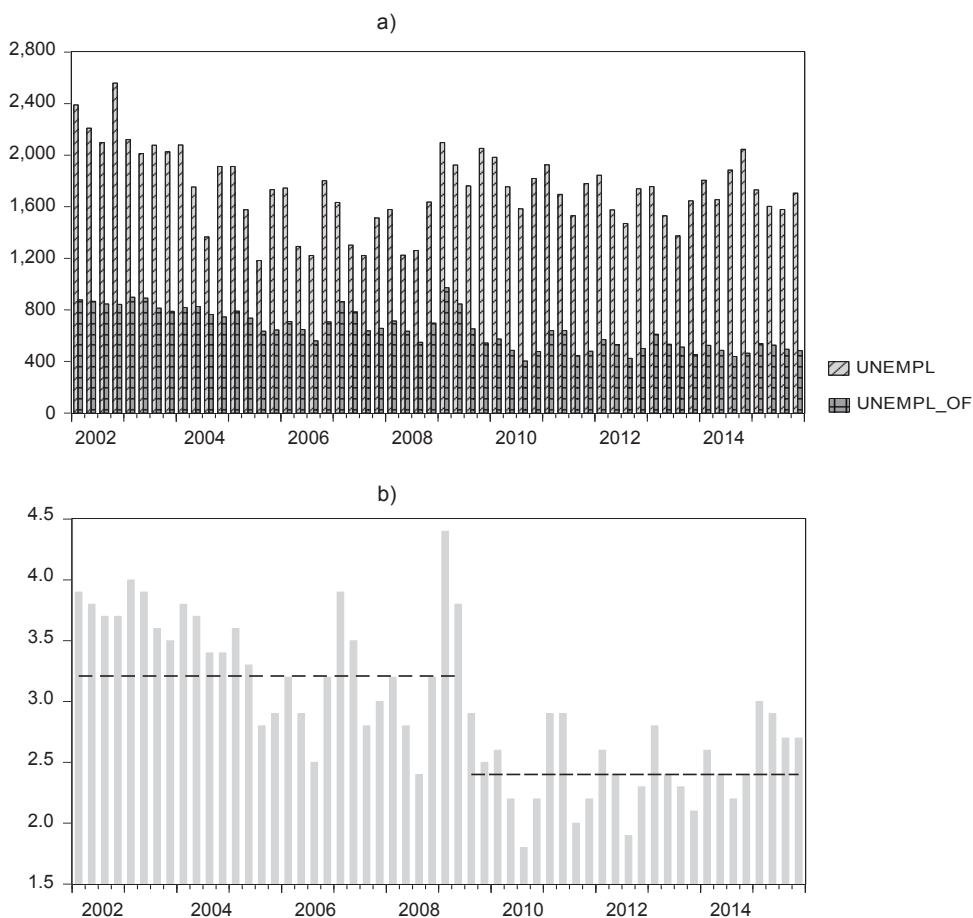


Source: data of the State Statistics Service of Ukraine, evaluations of the authors.

Studying the registered unemployment rate in Ukraine *UROF* and relationship between it and the economic activity of population, we observe a negative correlation coefficient (Table 2), but we should note that this relationship weakens after 2009. The exposed trends are also accompanied by a weakening of the connection between *UR* and *UROF*.

Generally, statistical analysis shows that since 2009 Ukraine has been experiencing a sharp decrease in the percentage of unemployed who are applying for unemployment benefits (Figure 5a). The calculations show that during years 2005–2008 about half of the actual unemployed became registered at employment centers, which is about 700 thousand people from 1.5 million unemployed, but starting from 2009 this number is only 30% (560 thousand from 1.7 million). As a result, despite the fact since 2009 that unemployment rate has increased by an average of 1.3% (Figure 2, Table 1), the registered unemployment rate UROF on the contrary decreased by an average of 0.8% (Figure 5b, Table 1).

**Figure 5 | Dynamics of a) the Number of Unemployed and the Number of Officially Registered Unemployed and b) of Registered Unemployment Rate**



Source: data of the State Statistics Service of Ukraine, evaluations of the authors.

Therefore, an empirical analysis shows that the increase in economic activity in Ukraine is caused by new entrants who are actively searching for a job, however, despite the fact that they are unemployed, they are not officially registered in employment

centres. It should be noted that at the end of the fourth quarter of 2015 their number has been about 1.2 million people.

### 3. Asymmetries

We conduct an empirical analysis of processes asymmetry on the Ukrainian labour market and difference in the persistence of positive and negative shocks. Of course, there are many types of shocks that have an impact on the processes of the labour market. In particular, those are labour supply shocks, labour demand shocks, technological shocks, wage shocks as well as shocks of aggregate demand and supply that include demographic shocks, migration shocks, shocks that cause structural changes in economy, real demand shocks, changes in taxes, welfare, factors of monetary policy and shocks at the currency markets, inflation expectations, and so on. Some of these shocks have a long-term impact, while others have a short-term impact, and moreover the value of these effects is different for different shocks (Olishevych, 2015). During the modelling we are going to consider specific average dynamic effect from various shocks and divide shocks into positive (those that cause positive deviation of an indicator) and negative (shocks with a negative sign) ones.

Estimation of the impact of shocks of different signs and measuring their correlation with future values of the indicators of the labour market are conducted by means of nonlinear threshold specifications, which interpret disturbance as unobservable components of a time series.

Asymmetric threshold-disturbance moving average model of the first order has the form (Wecker, 1987)

$$y_t = u_t + \beta^+ u_{t-1}^+ + \beta^- u_{t-1}^-, \quad (1)$$

where  $u_t$  defines a sequence of independent identically distributed random variable,  $u_t^+ = \max\{u_t, 0\}$  – sequence of positive innovation,  $u_t^- = \min\{u_t, 0\}$  – sequence of negative innovation,  $\beta^+$  i  $\beta^-$  – unknown model parameters. When the two filters of the asymmetric model are identical ( $\beta^+ = \beta^-$ ), then an asymmetric model TDMA (1) is reduced to a symmetric MA model.

Asymmetrical first order threshold-disturbance autoregressive model can be represented as a nonlinear model, which includes system (Elwood, 1998)

$$y_t = m + y_t^p + y_t^n, \quad (2)$$

where  $m$  – constant,  $y_t^p$  – unobserved component that receives all non-negative shocks to the observed variable and  $y_t^n$  – unobserved component that receives all the negative shocks:

$$y_t^p = \varphi_p y_{t-1}^p + u_t \quad \text{and} \quad y_t^n = \varphi_n y_{t-1}^n \quad \text{for all } u_t > 0; \quad (3)$$

$$y_t^n = \varphi_n y_{t-1}^n + u_t \quad \text{and} \quad y_t^p = \varphi_p y_{t-1}^p \quad \text{for all } u_t < 0. \quad (4)$$

If  $\varphi_p = \varphi_n$ , then TDAR(1) model (2)–(4) is equivalent to the standard AR(1) model. If  $\varphi_p \neq \varphi_n$ , then an effect of positive shocks influence differs from the effects of negative shocks influence and threshold specification characterizes asymmetry.

Let's verify the symmetry of reaction to positive and negative shocks of labour market indicators based on the evaluation and analysis of TDMA and TDAR models. Research is conducted for level of the variables and their natural logarithms, the first difference of the series and their natural logarithms and for seasonal difference. It is worth noting that a time trend was previously eliminated from all series and they were seasonally adjusted (depending on detected statistical properties of a series or using regression specifications with dummy variables, which determine the seasonal factors or by seasonally adjusted moving average multiplicative methods). Testing of stationarity was made on the basis of ADF unit root test, PP and KPSS tests. Table 4 shows some results of the modelling. In particular, they show parameters estimation of asymmetric models and corresponding symmetric models, for which both coefficients are identical, as well as meaning of the likelihood ratio of the test statistic. Estimation was performed using conditional maximum likelihood (ML).

**Table 4 | Results of Symmetric and Asymmetric Models Comparison, Testing of Asymmetry**

Series	Symmetric MA Model		Asymmetric TDMA Model			LR-Statistic
	$\beta$	$(\sigma_s)^2$	$\beta^+$	$\beta^-$	$(\sigma_{as})^2$	
$\Delta \log LFPR$	-0.67	0.0049	-0.65	-0.82	0.0046	2.8431*
UR	0.77	29.6603	0.99	0.61	27.3423	3.8994**
UROF	0.87	2.7179	0.99	0.77	2.6724	0.8287
$\Delta_4 \log PROD$	0.81	0.1042	0.94	0.66	0.1032	0.4332
$\Delta_4 \log EMPL$	0.27	0.0141	-0.05	0.55	0.0128	4.4352**
$\log RGDP$	-0.30	0.1376	-0.01	-0.99	0.0808	5.8556**
Series	Symmetric AR model		Asymmetric TDAR model			LR-Statistic
	$\varphi$	$(\sigma^{\wedge}_s)^2$	$\varphi_p$	$\varphi_n$	$(\sigma^{\wedge}_{as})^2$	
$\Delta \log LFPR$	-0.29	0.0065	-0.14	-0.42	0.0060	3.876**
UR	0.01	54.6645	0.08	-0.07	34.997	21.850***
UROF	0.01	5.2654	0.09	-0.04	3.8151	15.786***
$\log PROD$	0.07	0.2367	0.02	0.01	0.1513	21.908***
$\Delta \log EMPL$	-0.12	0.0105	0.02	-0.26	0.0100	2.735*

Note: \*\*\*, \*\* and \* indicate significance of the coefficients at 1%, 5% and 10% levels.

Source: evaluations of the authors.

Testing of asymmetry based on LR likelihood ratio of the test statistic (Wecker, 1987) demonstrates a significant asymmetry in the persistence of shocks to all investigated labour market indicators. Modelling shows that both indices of the unemployment rate

are asymmetric in levels and have asymmetric annual growth rates. In particular, negative economic disturbances have a longer effect on cyclical unemployment (deviation of unemployment rate from its natural level, trajectory of which we have defined considering trending and seasonal series properties) than positive. At the same as modelling shows, influence of negative shocks on unemployment defined by the ILO and registered level is the same, while positive shocks affect the unemployment rate more than its registered level.

Labour productivity increases during periods of economic growth as well as during phases of recession. However, we should note that the estimate of autoregressive parameter  $\varphi_p$  is twice as big as the corresponding estimate of  $\varphi_n$ , and therefore, it can be stated that labour productivity responds stronger and longer to positive technological shocks. The modelling also shows that positive deviation from the natural trajectory causes further increase in labour productivity and thus creates trend, while negative deviations are compensated in the next period. At the same time according to the results of TDMA model rates of productivity change ( $\Delta_4 \log PROD$ ) do not show an asymmetric reaction.

Coefficient of participation in the labour force reveals asymmetry in the first difference of series logarithm. The growth rate of economically active population percentage responds differently to positive and negative shocks. In particular, the positive disturbances causing their slight decrease, while negative disturbances increasing them. However, according to the evaluation results, negative disturbances have three times larger and longer impact on the change in economic activity percentage than positive. During crises households – in order to prevent the loss of income – increase their labour supply (young people and the elders show increased activity in job searching), and that leads to a growth of labour force participation rate.

Registered unemployment rate is characterized by asymmetry of the long-term responses to shocks of various signs obtained from autoregressive model structure, while instantaneous effects *UROF* are symmetrical. Meanwhile, asymmetric reactions of unemployment rate *UR* is obtained from both models.

#### 4. Nonlinearity

Asymmetric behaviour of Ukrainian LFPR indicates the necessity of nonlinear econometric analysis conduction and implementation of comprehensive statistical study of the time series properties. Results of LFPR stationarity in Ukraine done on the basis of augmented Dickey–Fuller unit root test, Phillips–Perron unit root test and Kwiatkowski–Phillips–Schmidt–Shin test demonstrate that LFPR series is integrated of the first order (ADF = -2.86, PP = -3.72, KPSS = 0.78 for  $\log LFPR$ ; ADF = -16.05, PP = -21.16, KPSS = 0.19 for  $\Delta \log LFPR$ ). It should be noted that because of non-stationarity of the proportion of economically active population the effectiveness of joblessness measuring by using unemployment rate is controversial because the labour supply response to macroeconomic shocks may vary and may depend on job prospects (Madsen, Mishra and Smyth, 2008).

As a result of the conducted econometric analysis, as well as taking into account experience of previous studies (Salamaliki and Venetis, 2014, Cengiz and Sahin, 2014)

we selected univariate smooth transition autoregressive model for modelling economic activity of population in Ukraine. STAR models make it possible to model processes for which at some period of time a specific series structure can dominate, which as a result of switching regime will gradually change into other structure (Lutkepohl *et al.*, 2004). The order of lags length, which will be included in a model, is chosen on the basis of the Akaike information criterion (AIC), the Hannan-Quinn criterion (HQ) and the Schwarz criterion (SC) comparison for the corresponding linear models. By taking into account seasonality in the series behaviour in the model we included a constant and seasonal variables  $S1$ ,  $S2$ ,  $S3$ , which take the value 1, respectively in the first, second and third quarters and zero for all other quarters. To account the shift effects taking place as a result of 2008 crisis and after the revolution events in 2014 the model includes certain dummy variables. Evaluation results of autoregressive models with different lags length show that a model which includes three previous delays is the best choice

$$\Delta \log LFPR_t = \alpha' Seas_t + \beta' D_t + \varphi' y_t + \theta' y_t G(s_t; \gamma, c) + u_t, \quad t = 1, \dots, T, \quad (5)$$

where  $Seas_t = (S1_t, S2_t, S3_t)'$  – a vector of seasonal dummy variables;  $y_t = (1, \Delta \log LFPR_{t-1}, \Delta \log LFPR_{t-2}, \Delta \log LFPR_{t-3})'$  – a vector of explanatory variables;  $D_t = (Shift\_D2008q4_t, Shift\_D2014q1_t, Impulse\_D2008q4_t, Impulse\_D2014q1_t)'$ ;  $\alpha = (\alpha_1, \alpha_2, \alpha_3)'$ ,  $\beta = (\beta_1, \beta_2, \beta_3, \beta_4)'$ ,  $\varphi = (\varphi_0, \varphi_1, \varphi_2, \varphi_3)'$  and  $\theta = (\theta_0, \theta_1, \theta_2, \theta_3)'$  – vectors of unknown parameters of the model,  $u_t \sim iid(0, \sigma^2)$  sequence of innovations. Transition function  $G(s_t; \gamma, c)$  is defined by the general logistic function

$$G(s_t; \gamma, c) = \frac{1}{1 + \exp(-\gamma \prod_{j=1}^N (s_t - c_j))}, \quad \gamma > 0, \quad (6)$$

which is a continuous function of the transition variable  $s_t$ , slope parameter  $\gamma$  and vector of location parameters  $c$ . Vector of location parameters  $c = (c_1, \dots, c_N)'$  defines threshold values between different time regimes, which are determined by different values of  $s_t$ .

To justify the correctness of using a nonlinear smooth transition model to describe the asymmetric behaviour of a series we use a common methodology for testing the null hypothesis of linearity for the alternative of LSTR-nonlinearity (Lutkepohl *et al.*, 2004). As potential transition variables we choose the elements of the set  $S = \{TREND, \Delta \log LFPR_{t-1}, \Delta \log LFPR_{t-2}, \Delta \log LFPR_{t-3}\}$  and conduct testing of nonlinearity for each element of  $S$ . As a result of tests we obtained  $p$ -values for the test statistics that are lower than the acceptable significant level by 5% for the three transition variables from  $S$  (Table 5), which shows nonlinearity of autoregressive correlations and justifies the need to use LSTR nonlinear models for modelling a coefficient of labour force participation rate.

Results of the research show that LSTR1 models with transition variables  $TREND$  or  $\Delta \log LFPR_{t-3}$  and LSRT2 model with transition variable  $\Delta \log LFPR_{t-1}$  may be adequate. It should be noted that LSTR1 and LSTR2 models are describing different types of behaviour. The first model ( $N = 1$ ) has two extreme regimes that differ from each other. In particular, if the transition variable is an indicator of transition between the phases



of the business cycle, one regime will correspond to the phase of rising in the business cycle, and the second is associated with the recession phase. LSTR2 model has two similar regimes for both large and small values of transition variable, while the middle regime is different (Lutkepohl *et al.*, 2004).

**Table 5 | Autoregressive Nonlinearity Test Results**

Hypothesis	TREND	$\Delta \log LFPR(-1)$	$\Delta \log LFPR(-2)$	$\Delta \log LFPR(-3)$
<b>p-value (F)</b>	0.0361**	0.0219**	0.8405	0.0213**
<b>p-value (F4)</b>	0.3242	0.0969*	0.4809	0.1371
<b>p-value (F3)</b>	0.6065	0.0720*	0.9676	0.1177
<b>p-value (F2)</b>	0.0024***	0.1055	0.5437	0.0378**
<b>Adequate model</b>	LSTR1	LSTR2	Linear	LSTR1

Note: \*indicates significance of the coefficients at 10%, \*\* – at 5%, \*\*\* – at 1%.

Source: evaluations of the authors.

In the stage of nonlinearity testing we got several possible nonlinear specifications, and the choice among them will be done during models estimation and evaluation. Parameters of STR models are estimated by the maximizing the conditional likelihood function and iterative algorithm BFGS. Calculations are done by using econometric package JMulTi. Estimation of initial values  $c$  i  $\gamma$ , and further estimation and evaluation of various smooth transition models indicate that LSTR2 model with transition variable  $\Delta \log LFPR_{t-1}$  is the best for describing the growth rate of the proportion of economically active population. The results of parameters estimation for this model which take into account seasonal and dummy variables along with results of estimation for linear autoregressive model are shown in Table 6.

Comparison of modelling results for linear and nonlinear case reveals a significant reduction of information criteria and standard error of a model as well as coefficients of determination increasing, confirming necessity of nonlinear modelling approaches application. Estimated values of location parameters determine the values at which the changes in the regime of population economic activity are conducted from periods of low growth rates for periods of high values. Modelling shows that the current rate of these changes responds differently to changes in the characteristics of previous states, and indicates that the values amplitude of previous change in labour force participation rate determines the shift in behaviour regime and smooth transition during the time period. Obtained estimated value of slope parameter  $\gamma = 3.2$ , which characterizes the smoothness of this transition is quite large indicating that the economic activity of the population quickly reacts to changes that take place in the labour market.

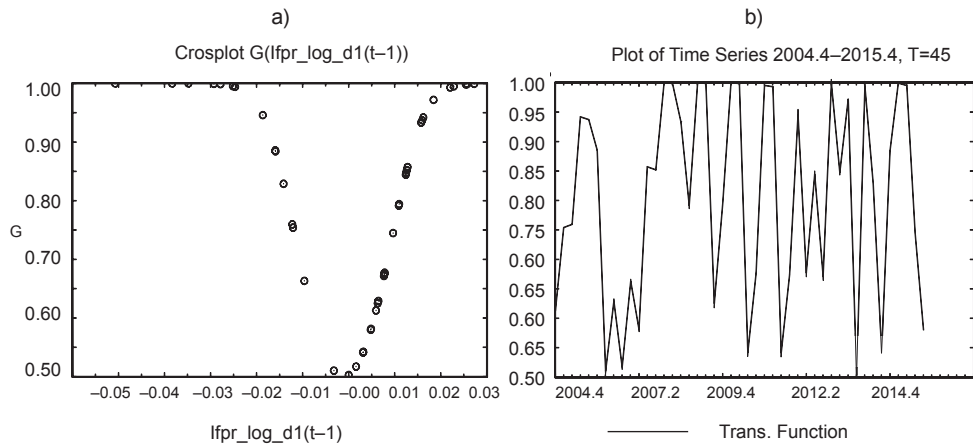
**Table 6 | Estimation Results of LSTR1 Model for Labour Force Participant Rate**

Variable	LSTR model		AR model	
	Coefficient	t-statistics (p-values)	Coefficient	t-statistics (p-values)
<b>Linear Part</b>				
<i>Const</i>	−0.0277	−4.1341 (0.0003)	−0.0236	−3.6281 (0.0008)
<i>Impulse_D2008q4</i>	−0.0163	−2.0399 (0.0513)	−0.0088	−1.2130 (0.2321)
<i>Impulse_D2014q1</i>	−0.0161	−2.0917 (0.0460)	−0.0390	−4.8811 (0.0000)
<i>Shift_D2008q4<sub>t</sub></i>	−0.0066	−2.6213 (0.0142)	0.0013	1.2243 (0.2278)
<i>Shift_D2014q1</i>	−0.0079	−0.2139 (0.0355)	−0.0025	−1.3519 (0.1838)
<i>S1</i>	0.0299	4.3337 (0.0002)	0.0326	2.7371 (0.0091)
<i>S2</i>	0.0375	7.3191 (0.0000)	0.0353	5.0602 (0.0000)
<i>S3</i>	0.0277	6.3376 (0.0000)	0.0282	2.3713 (0.0225)
$\Delta \log LFPR(-1)$	4.2333	3.3889 (0.0022)	−0.7242	−5.5316 (0.0000)
$\Delta \log LFPR(-2)$	1.4701	3.9535 (0.0005)	−0.4926	−3.1526 (0.0030)
$\Delta \log LFPR(-3)$	1.3119	3.6457 (0.0011)	−0.5188	−3.8940 (0.0004)
<b>Nonlinear Part</b>				
<i>Const</i>	0.0087	1.0025 (0.3250)	–	–
$\Delta \log LFPR(-1)$	−5.0271	−4.1215 (0.0003)	–	–
$\Delta \log LFPR(-2)$	−2.0132	−4.4659 (0.0001)	–	–
$\Delta \log LFPR(-3)$	−2.0421	−4.2958 (0.0002)	–	–
$\gamma$	3.1985	4.1498 (0.0003)	–	–
$c_1$	−0.0011	−0.0524 (0.9586)	–	–
$c_2$	−0.0011	−0.0524 (0.9586)	–	–
<b>Diagnostic Statistics</b>				
<b>AIC</b>	−9.8318		−6.2467	
<b>SC</b>	−9.1091		−5.8339	
<b>HQ</b>	−9.5624		−6.0884	
<b>R<sup>2</sup></b>	0.9305		0.7889	
<b>Adjusted R<sup>2</sup></b>	0.9288		0.7374	
<b>SD of Residual</b>	0.0063		0.0097	

Source: evaluations of the authors.

Figure 6 shows a plot of evaluated transition function  $G(\gamma, c, s_t)$  as a function of the transition variable  $s_t = \Delta \log LFPR_{t-1}$  (Figure 6a) and dynamics of values for 2004–2015 years (Figure 6b).

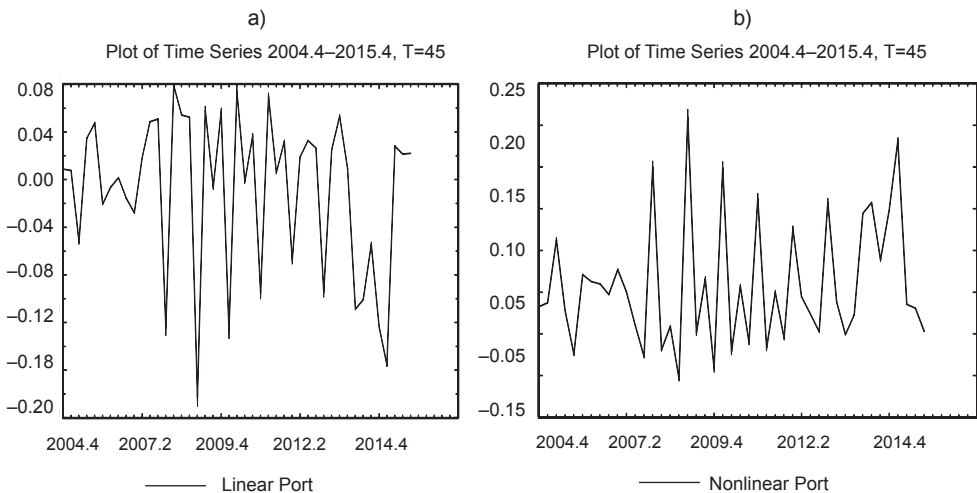
**Figure 6 | Transition Function of Model (5)–(6)**



Source: evaluations of the authors.

Plot of transition function as function of transition variable observation  $\Delta \log LFPR_{t-1}$  shows that the transition is really smooth and relatively asymmetric around the estimated location value. Figure 7 shows the linear  $\phi'y_t$  and nonlinear  $\theta'y_t$   $G(\gamma, c, s_t)$  parts of a series.

**Figure 7 | Linear and Nonlinear Parts of a Series  $\Delta \log LFPR_t$  Fitted on the Basis of LSTR2 Model**



Source: evaluations of the authors.

A comparison of the actual values of a series  $LFPR_p$  and values fitted for the two models, namely linear AR model and values  $\phi'y_t + \theta'y_t G(\gamma, c, s_t)$  defined on the basis of nonlinear LSTAR model that are respectively the sum of linear and nonlinear parts shows that the estimates of LSTAR model give better *ex post* forecasts than their linear (AR) approach.

Once the STR model is estimated, we should check if it adequately characterizes the nonlinearity originally found in the data and test whether there is some non-linearity that was not described by the estimated STR model, and also to examine parameter constancy of the evaluated model. Instability of the model parameters may yield important information about causes of possible misspecification of the model or change of economic relationship that describes the model over time. Test results of no additive nonlinearity and stability of the model parameters which were based on the use of appropriate LM-type statistics (Lutkepohl *et al.*, 2004) are shown in Table 7. Conducted testings indicate on the stability of the model parameters and absence of nonlinearity, and therefore on the adequacy of choosing LSTR2 model for describing the dynamics of percent of the economically active population in Ukraine.

**Table 7 | Evaluation Results of LSTR Model**

Test of no additive nonlinearity		Test of no error autocorrelation (LM)	
		Test Statistic	p-value
p-value (F) = 0.3959		F (1 lag) = 0.6928	0.4114
p-value (F4) = 0.2941		F (2 lags) = 0.3367	0.7168
p-value (F3) = 0.2210		F (3 lags) = 0.5324	0.6638
p-value (F2) = 0.7829		F (4 lags) = 0.4803	0.7499
Test of parameter constancy		ARCH-LM test (8 lags)	
Test Statistic	p-value	Test Statistic	p-value
F (H1) = 1.9477	0.1221	$\chi^2 = 1.8546$	0.6031
F (H2) = 1.9491	0.1169	F = 0.6468	0.5898
Normality Test			
LJB = 0.2598	p-value = 0.8782	Skewness = 0.0877	Kurtosis = 3.3283

Source: evaluation of the authors.

We carried out a diagnosis of constructed LSTAR model based on the investigation of its residuals properties. The results of testing on autocorrelation in some residual of a model (5)–(6), check of the null hypothesis on absence of ARCH effects in the residues and testing the normality of their distribution based on Lomnicki–Jarque–Bera normality test

are shown in Table 7. The results of the tests indicate the residues non-autocorrelation, normality of their distribution and absence of conditional heteroskedasticity.

Therefore, the results of statistical tests confirm the adequacy of conducted modelling and correctness of using the nonlinear logistic smooth transition model to describe the behaviour of the labour force participation rate in Ukraine.

## 5. Conclusions

The effectiveness of socio-economic policy implementation in Ukraine requires a development of qualitative models that allow explaining and predicting trends in unemployment and active participation of population in the labour market. The conducted empiric research shows that the inverse relationship among population economic activity and unemployment rate in Ukraine is short-termed. Fluctuations of labour force participation rate are caused by seasonal fluctuations in unemployment rate, while in the long run Ukrainians show increased economic activity and increase in the rate of entering in the labour force. The results of an econometric analysis of labour market indicators show asymmetric responses of shocks with different signs and indicate that negative disturbances increase their volatility much more than positive, which requires consideration asymmetry in their response to various market conditions changes in modelling and predicting future trends of development processes in social and labour sphere. It is found that prolonged periods of economic instability and recession during 2002–2013 years and a significant asymmetric reaction of economic activity rate increase in response to negative macroeconomic shocks. These are the causes of participation rate growth that is observed during this period and partially compensate the negative impact of the decline in working-age population. Developed nonlinear logistic smooth transition model explains the behaviour of population economic activity on the labour market. Modelling results quantitatively characterize the dynamic changes in modes of behaviour of a participation in the labour force coefficient from periods of low growth rates to periods of high values indicating that the current growth rate of these changes responds differently to changes in characteristics of previous states. Modelling shows that an economic activity of population quickly reacts to changes that take place in the labour market. In times of crisis Ukrainian households increase labour supply and show increased activity in job search in order to prevent the decline of their income. Created model makes it possible to increase the adequacy of modelling and forecasting of future trends on the labour market in Ukraine in order to implement measures designed to maintain and further improve productivity and economic activity rate.

In order to increase economic activity of population in Ukraine it is necessary to introduce changes in the taxation system of labour remuneration that would reduce informal employment (in Ukraine it is about 23% of all employees), growth of employment in the official sector. Considering the fact that the highest unemployment rate in Ukraine is observed among bachelors it is advisable to encourage the creation of temporary jobs, that is a rarity in Ukraine and which would be available to students with a bachelor degree that continue studying. That would increase the employment rate among young

people. Increasing the labour force participation rate can also be achieved through the promotion of employment among the inactive part of population not included in the workforce, such as older people, women, the disabled and ethnic minorities. At the same time the stabilization of political situation, attraction for foreign investments and positive technological changes will make it possible to increase labour productivity and reduce the outflow of labour force abroad. Considering the complicated demographic situation and high expected load on younger generation in Ukraine it is also necessary to pay more attention to quality of education and to modernize its direction and all that in the future will lead to the increase of labour productivity in the country.

Timeliness and effectiveness of such measures in the long term will allow to prevent threats to the national labour market that are associated with the influence of negative demographic trends and an aging population.

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