EVIDENCE OF ASYMMETRIES AND NONLINEARITY OF UNEMPLOYMENT AND LABOR FORCE PARTICIPATION RATE IN UKRAINE

Abstract:
The effectiveness of socio-economic policy in Ukraine requires the development of appropriate models that will allow us to explain the labor market dynamics. On the basis of analysis of TDMA and TDAR models the asymmetry effect of a number of labor market indicators on shocks with different signs were analyzed and was shown that negative disturbances increase their volatility much more than positive. It is established that long periods of economic instability and recession and also a significant asymmetric reaction in response to positive and negative macroeconomic shocks are reasons of growth of economic activity percentage that is observed in Ukraine over 2002–2013 years. For modelling the asymmetric behavior of economic activity of population a nonlinear logistic smooth transition autoregressive model is constructed. The evaluation results quantitatively characterize the dynamic changes in the modes of the labor force participation rate behavior from periods of low growth rates to periods of high values.

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

JEL Classification: C 30, E 24

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 exist, with both positive and negative consequences. The existing significant discrepancies in the employment structure, wages and labor 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. Ukrainian labor market is characterized by asymmetry of natural, social and migration reproduction of the population and lack of coordination between professional and qualification structure of human resources of the region and needs of regional labor markets. Besides spatial asymmetry the labour market is also characterized by asymmetry in processes of adaptation to changing market conditions. In this regard, an important issue is the development and analysis of nonlinear economic and mathematical models which allow 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.

Works of I. Aksionova, V. Vitlinskiy, V. Vovk, A. Hanchuk, O. Yermolenko, A. Kolot, Y. Krasnonosova, O. Kupets, I. Lukianenko, A. Maslov, V. Miga, S. Panchyshyn, O. Chernyak, V. Fedorenko, O. Shubna and many others cover such issues as imbalance and asymmetry of economic processes in the domestic labour market. Researchers substantiate the availability of socio-demographic, informational, structural, market, territorial and gender asymmetry in the labour market. Among others, Yermolenko (2014) considers various issues of spatial asymmetry of regional labor resources placement, defines indicators and factors of asymmetry in the field of social and labor relations. Scientists confirm significant dependence of economy on inconsistent policy decisions, aging of production assets due to insufficient funding of the production sector (Stolyarchuk, 2009), the limited effect of foreign direct investment and asymmetry in the distribution of productive forces (Miga, 2012), underutilization of labour resources and nonoptymality of employment allocation (Kolot, 2012), a significant level of unemployment, poor quality of the work proposed, informal sector of employment problems (Maslov, 2012, Krasnonosova and Yermolenko, 2013).

Analysis and study of asymmetric and nonlinear behavior of labor market indicators for different countries are based on an investigation of econometric time series models. 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 modeling 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 autoregressions and models where the transition variable is GDP growth and indicated that nonlinearities are induced by cyclical asymmetries. Hotchkiss and Robertson (2012) by using the standard labour-leisure choice model found that labor force participation decisions across demographic groups in response to changes in labor market conditions are asymmetric. Cengiz and Sahin (2014) evaluated smooth autoregressive transition models for Turkish labor force participation rates and showed a nonlinearity of behavior of participation rates for men and women.

2. Data and empirical analysis

We conduct an empirical analysis and econometric modeling of behavior of the key labor market indicators to identify the characteristics of their asymmetric dynamics, 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 2002-2014, obtained from statistical reports of 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 centers); *LFPR* (labour force participation rate, in %); *EMPL* (employed population in thousands persons); *PROD* (productivity, in thousands of UAH per person); *UNEMPL* (number of unemployed population in thousands persons); *UNEMPLOF* (number of officially registered unemployed persons in thousands persons). In Table 1 there are some of their statistical characteristics.

Researches emphasize of criticality of demographic trends in Ukraine and their impact on the labour market prospects (Aksionova, 2012, Tsizhma, 2013). Over the past decades due to low birth rate, high mortality rate and emigration of working-age population we can observe a sharp population decline and ageing. Moreover, nowadays Ukrainian labor market demonstrates growth of unemployment rate, which is characterized by unevenness of gender, age and social status. However, despite these negative phenomena in the same period in Ukraine we can observe an increase of population economic activity and rising of labor force participation rate, which makes possible to prevent a rapid fall in labor force.

Analysis of population economic activity and unemployment rate as well as research of relationships among them during different periods of business cycle were a point of interest for many scientists all over the world. In particular, Kakinaka and Miyamoto (2012) were estimating 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 modeling interrelation between labor 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 labor force or not. However, other researches (Hernández and Orraca, 2009) show 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 business cycles, and in the long term prospect a relationship between the LFPR and unemployment may not be traced.

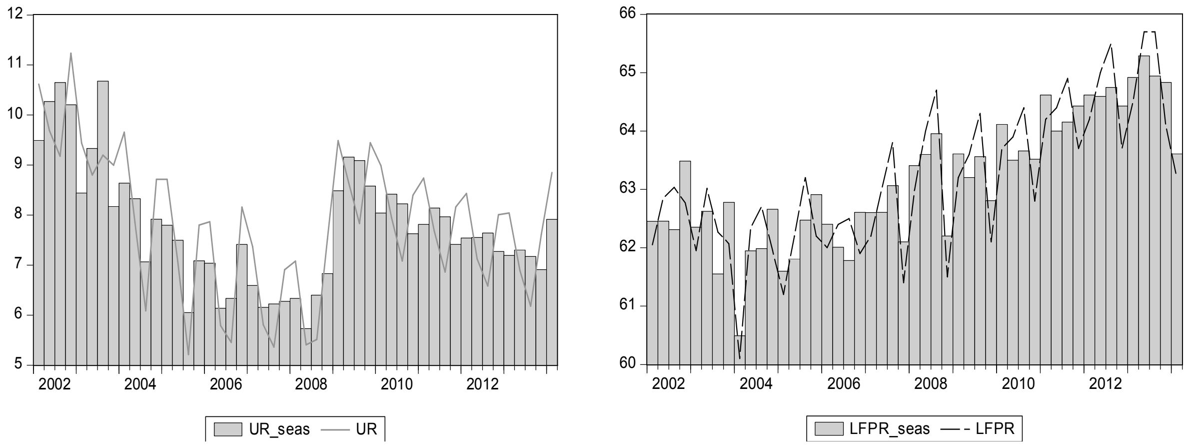
Table 1
Statistical Characteristics of Population Unemployment and Economic Activity Indicators

Period	Mean	Minimum	Maximum	Standard Deviation
Unemployment Rate (*UR*)				
2002—2004	9.46	7.85	11.23	0.93
2004—2008	6.76	5.21	8.71	1.20
2009—2013	7.95	6.17	9.48	0.92
Registered unemployment rate (*UROF*)				
2002—2004	3.76	3.50	4.00	0.15
2004—2008	3.21	2.40	4.40	0.48
2009—2013	2.40	1.80	2.90	0.33
Percentage of the unemployed registered in employment centers (*UROF/UR*)				
2002—2004	40.04	32.93	47.10	3.91
2004—2008	46.59	37.17	60.28	6.25
2009—2013	30.77	25.41	37.75	4.04
Labour force participation rate (*LFPR*)				
2002—2004	62.24	60.10	63.03	0.85
2004—2008	62.54	61.20	64.70	0.93
2009—2013	64.13	62.10	65.70	0.92

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

Figures 1a and 1b show the behaviour of *UR* series and *LFPR* series as well as dynamics of their seasonally adjusted series (using the multiplicative seasonal adjustment method CensusX12).

Figure 1
Dynamics of a) unemployment rate (series UR_t) and b) labor force participant rate (series $LFPR_t$) during years 2002-2014



a) b)

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

In Ukraine, instability of the labor 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 2014 exists between unemployment rate and coefficient of labour force participation (Table 2). Also after 2009 inverse relationship between *UR* and *LFPR* strengthened. If by 2008 the correlation factor was 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 labor force participation factor.

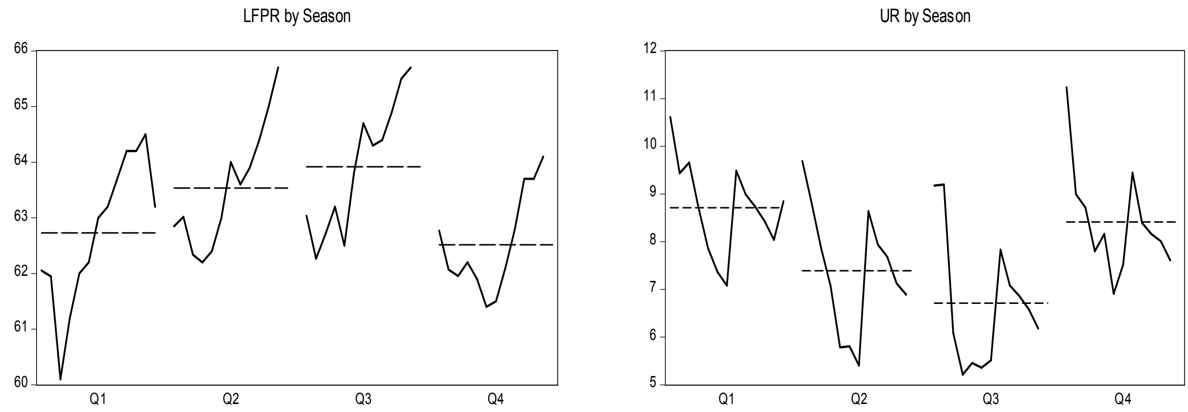
Table 2
The Correlation Coefficients among Labor Force Participation Rate, Unemployment Rate Defined by ILO and Registered Unemployment Rate

Period	Corr [*LFPR*, *UR*]	Corr [*LFPR*, *UROF*]	Corr [*UR*, *UROF*]
2002Q1 – 2008Q4	-0.4819 (p-value = 0.0094)	-0.4367 (p-value = 0.0201)	0.7847 (p-value = 0.0000)
2009Q1 – 2014Q1	-0.8758 (p-value = 0.0000)	-0.3140 (p-value = 0.1656)	0.5940 (p-value = 0.0045)

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 2), which may be caused by anticipation of bad prospects for employment and the discouraged effect of individual employees in the short term.

Figure 2
The seasonal behavior of the labor force participation rate and unemployment rate



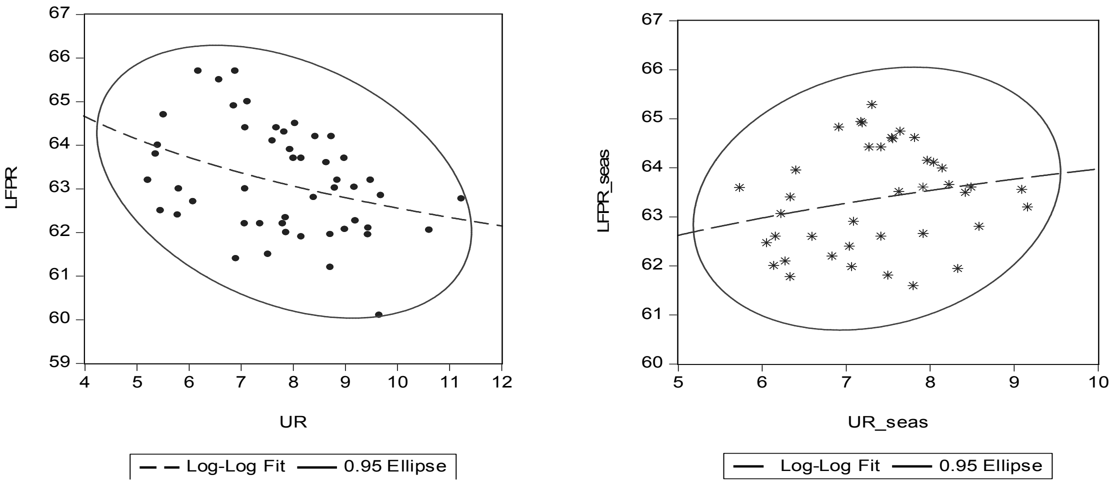
a) b)

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

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, and we get opposite conclusions and positive correlation coefficient (Figure 3).

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.

Figure 3
The correlation between LFPR and UR

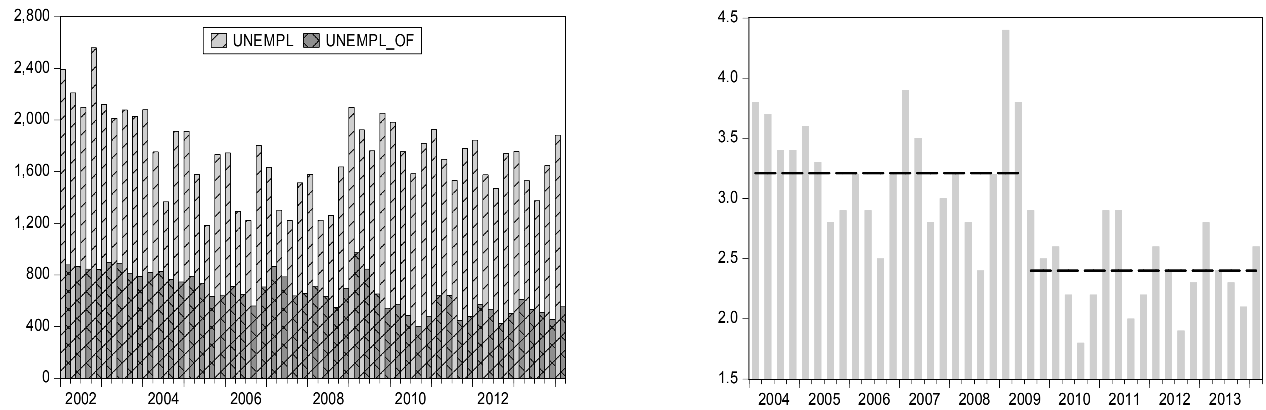


a) b)

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 4a). 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 that unemployment rate UR since 2009 has increased by an average of 1.3% (Figure 1a, Table 1), the registered unemployment rate UROF on the contrary decreased by an average of 0.8% (Figure 4b, Table 1).

Figure 4
Dynamics of a) the number of unemployed and the number of officially registered unemployed; b) the dynamics of registered unemployment rate



a) b)

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

Therefore, empirical analysis shows that the increase in population economic activity in Ukraine is caused by joining new employees who are actively searching for a job however, despite the fact that they are unemployed, they are not officially registered in employment centers. Should be noted that at the end of the second quarter of 2014 their number has been about 1.3 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. Estimation the impact of shocks of different signs and measuring their correlation with future values of the indicators of the labor market are conducted by means of nonlinear threshold specifications, which interpret disturbance as unobservable components of a times 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, β^+ i β^- – unknown model parameters. When the two filters of the asymmetric model are identical ($\beta^+ = \beta^-$), than 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)

$$y_t = m + y^p_t + y^n_t, \quad (2)$$

where m – constant, y^p_t – unobserved component that receives all non-negative shocks to the observed variable and y^n_t – unobserved component that receives all the negative shocks:

$$y^p_t = \varphi_p\, y^p_{t-1} + u_t \text{ and } y^n_t = \varphi_n\, y^n_{t-1} \text{ for all } u_t > 0; \quad (3)$$

$$y^n_t = \varphi_n\, y^n_{t-1} + u_t \text{ and } y^p_t = \varphi_p\, y^p_{t-1} \text{ for all } u_t < 0. \quad (4)$$

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.

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. 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 Dickey-Fuller unit root test. Table 3 shows some results of the modeling. In particular, parameters estimation of asymmetric models and corresponding symmetric models, for which both coefficients are identical, as well as meaning of the likelihood ratio test statistic. Estimation was performed using conditional maximum likelihood (ML).

Testing of asymmetry based on LR likelihood ratio 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 (International Labor Organization) and registered level is the same, while positive shocks affect the unemployment rate more than its registered level.

Table 3
Results of Symmetric and Asymmetric Models Comparison, Testing of Asymmetry

Series	Symmetric MA Model		Asymmetric TDMA Model			LR-Statistic
	β	$(\sigma_S)^2$	β^+	β^-	$(\sigma_{as})^2$	
Δ 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
Δ4 log *PROD*	0.81	0.1042	0.94	0.66	0.1032	0.4332
Δ4 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
	φ	$(\sigma\hat{}_S)^2$	φp	φn	$(\sigma\hat{}_{as})^2$	
Δ 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***
Δ 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.

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 φ_p is twice as big as the corresponding estimate of φ_n, and therefore, it can be stated that labour productivity stronger and longer responds 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.

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 crisis periods households in order to prevent loss of income increase their labour supply, that is why young people and the elders show increased activity in job searching, that cause a growth of labour force participation rate.

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, demonstrate that *LFPR* series is integrated of first order (DF = –3.27 for *log LFPR*; DF = –14.89 for *Δ log LFPR*). It should be noted that because of nonstationarity proportion of economically active population the effectiveness of joblessness measuring by using unemployment rate is controversial because the labor supply response to macroeconomic shocks may vary and depend on job prospects (Gustavsson and Osterholm, 2012, 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, Lukyanenko and Zuk, 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 are 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. Taking into account seasonality in the series behaviour in the model was 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. Evaluation results of autoregressive models with different lags length show that a model which includes three previous delays is the best choice

$$\Delta \log LFPR_t = \boldsymbol{\alpha}' \boldsymbol{Seas}_t + \boldsymbol{\varphi}' \boldsymbol{y}_t + \boldsymbol{\theta}' \boldsymbol{y}_t\, G(s_t; \gamma, \boldsymbol{c}) + u_t\ , \quad t = 1,...,T, \tag{5}$$

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

$$G(s_t;\ \gamma,\ \boldsymbol{c}) = 1\ /\ (1 - exp\ (-\gamma \prod_{k=1}^{K}\ (s_t - c_k)\ )\ )\ , \qquad \gamma > 0, \tag{6}$$

which is a continuous function of the transition variable s_t, slope parameter γ and vector of location parameters $\boldsymbol{c}$. Vector of location parameters $\boldsymbol{c} = (c_1,...,\ c_K)'$ 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 a p - values for the test statistics that are lower than the acceptable significant level by 5% for the first three transition variables from *S* (Table 4), which shows nonlinearity of autoregressive correlations and justifies the need to use LSTAR nonlinear models for modelling a coefficient of labour force participation rate.

Table 4
Autoregressive Nonlinearity Test Results

Hypothesis	*TREND*	$\Delta\log LFPR(-1)$	$\Delta\log LFPR(-2)$	$\Delta\log LFPR(-3)$
p-value (F)	0.0356**	0.0482**	0.0136**	0.7895
p-value (F4)	0.0945	0.9923	0.0708	0.5624
p-value (F3)	0.0312**	0.0427**	0.9221	0.5951
p-value (F2)	0.5276	0.0212**	0.0030***	0.6839
Adequate model	LSTR2	LSTR1	LSTR1	Linear

Note: **indicates significance of the coefficients at 5%, *** – at 1%.
Source: evaluations of the authors.

Results of the research show that LSTR1 models with transition variables $\Delta\ \log LFPR_{t-1}$ or $\Delta\ \log LFPR_{t-2}$ and LSRT2 model with transition variable *TREND* may be adequate. Should be noted that LSTR1 and LSTR2 models describing different types of behaviour. The first model (K = 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, 2004).

Since on the stage of nonlinearity testing we got several possible nonlinear specifications, 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 *γ*, and further estimation and evaluation of various smooth transition models indicate that LSTR1 model with transition variable Δ 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 variables along with results of estimation for linear autoregressive model are shown in Table 5.

Table 5
Estimation Results of LSTR1 Model for Labor Force Participant Rate

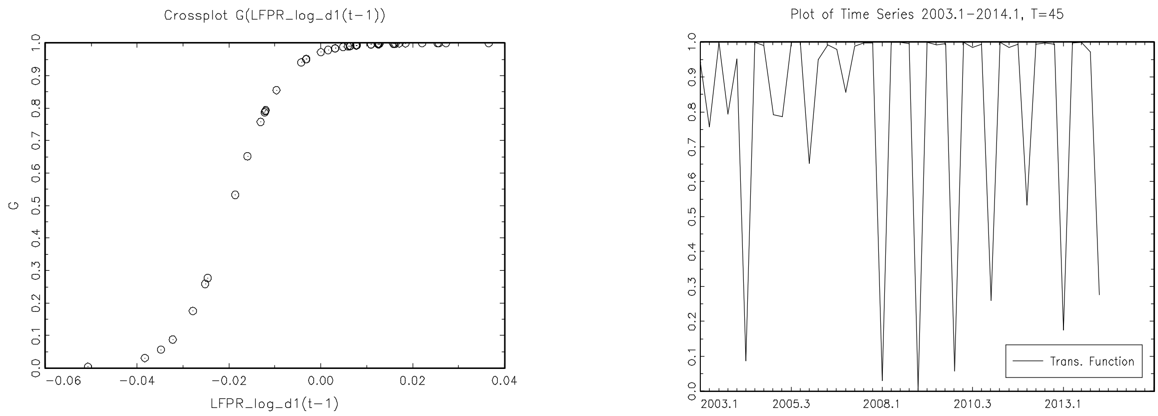
Variable	LSTR model		AR model	
	Coefficient	t-statistics (p-values)	Coefficient	t-statistics (p-values)
Linear Part				
Const	-0.0022	-0.1012 (0.9200)	-0.0240	2.8353 (0.0073)
S1	0.0056	0.8753 (0.3880)	0.0280	1.7519 (0.0879)
S2	0.0280	4.1089 (0.0003)	0.0398	5.5308 (0.0000)
S3	0.0194	3.3998 (0.0018)	0.0307	1.8977 (0.0654)
Δlog *LFPR(-1)*	-0.2232	-0.3525 (0.7268)	-0.7273	-5.20321 (0.0000)
Δlog *LFPR(-2)*	0.2282	2.0112 (0.0451)	-0.4622	-2.7060 (0.0101)
Δlog *LFPR(-3)*	-0.8898	-1.6784 (0.1030)	-0.5523	-3.9273 (0.0004)
Nonlinear Part				
Const	0.0134	-0.5666 (0.5749)	—	—
Δlog *LFPR(-1)*	0.1911	-0.3179 (0.7526)	—	—
Δlog *LFPR(-2)*	-0.5434	-2.2655 (0.0304)	—	—
Δlog *LFPR(-3)*	0.4452	0.7986 (0.4304)	—	—
γ	3.4979	2.2352 (0.0257)	—	—
c	-0.0193	-2.9427 (0.0060)	—	—
Diagnostic Statistics				
AIC	-9.4007		-6.3688	
SC	-8.8787		-6.0877	
HQ	-9.2061		-6.2640	
R^2	0.8757		0.7980	
Adjusted R^2	0.8754		0.7661	
SD of Residual	0.0081		0.0093	

Source: evaluations of the authors.

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 value of location parameter $c = -0.019$ determines the value 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 from its low to high levels. Obtained estimated value of slope parameter $\gamma = 3.21$, which characterizes the smoothness of this transition is quite large, indicating that the economic activity of the population quickly react to changes that take place in the labour market.

Figure 5 shows a plot of evaluated transition function $G\ (\gamma,c,s_t) = 1\ /\ (1-exp\ (-\gamma\ (s_t - c))$ as a function of the transition variable $s_t = \Delta\log\ LFPR_{t-1}$ (Figure 5) and dynamics of values for 2003—2014 years (Figure 5b).

Figure 5
Transition function of model (5) - (6)

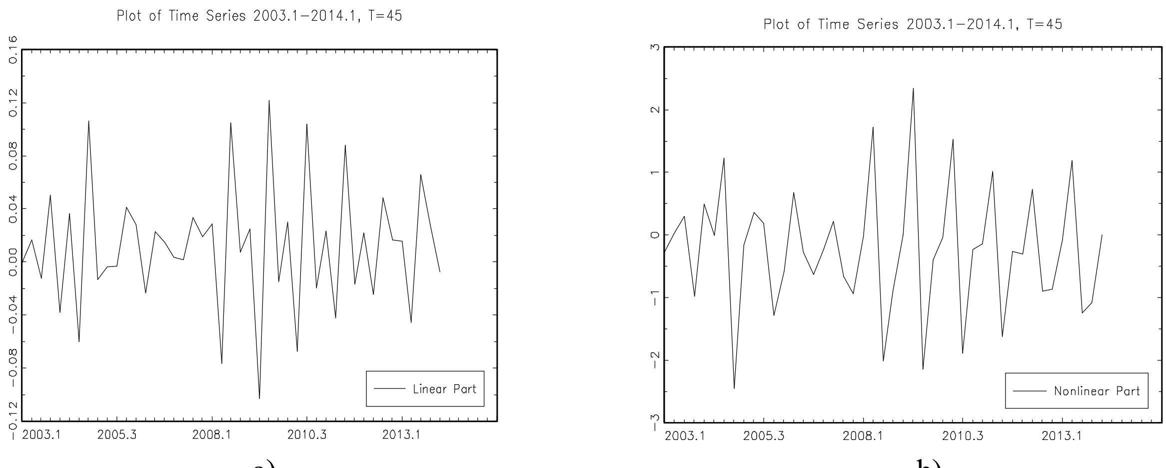


a) b)

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 symmetric around the estimated location value. Figure 6 shows the linear $\boldsymbol{\varphi}'\boldsymbol{y}_t$ and nonlinear $\boldsymbol{\theta}'\boldsymbol{y}_t\ G\ (\gamma,\ c,\ s_t)$ parts of a series.

Figure 6
Linear and nonlinear parts of a series $\Delta\ log\ LFPR_t$, fitted on the basis of LSTR1 model



a) b)

Source: evaluations of the authors.

A comparison of the actual values of a series $LFPR_t$, and values fitted for the two models, namely linear AR model and values $\boldsymbol{\varphi}'\boldsymbol{y}_t + \boldsymbol{\theta}'\boldsymbol{y}_t\ G\ (\gamma,c,s_t)$, 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 6. Conducted testings indicate on the stability of the model parameters and absence of nonlinearity, and therefore on the adequacy of choosing LSTAR1 model for describing the dynamics of percent of the economically active population in Ukraine.

Table 6
Evaluation Results of LSTR Model

Test of no additive nonlinearity		Test of no error autocorrelation (LM)	
		Test Statistic	p-value
p-value (F) = 0.6364		F (1 lag) = 0.7353	0.3980
p-value (F4) = 0.3990		F (2 lags) = 0.3680	0.6954
p-value (F3) = 0.9534		F (3 lags) =0.5199	0.6723
p-value (F2) = 0.2715		F (4 lags) =0.7041	0.5969
Test of parameter constancy		ARCH-LM test (8 lags)	
Test Statistic	p-value	Test Statistic	p-value
F (H1) = 1.1917	0.3549	$\chi 2$ = 3.4271	0.9048
F (H2) = 1.2048	0.4142	F = 0.4721	0.8653
Normality Test			
JB=1.6468		p-value = 0.4389	

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 6. 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 modeling and correctness of using the nonlinear logistic smooth transition model to describe the behavior of the labor force participation rate in the 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-term. 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 labor 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 labor sphere. It is found that prolonged periods of economic instability and recession during 2002—2013 years and a significant asymmetric reaction of economic activity percent increase in response to negative macroeconomic shocks are causes of participation in the labor force coefficient 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 behaviour of population economic activity on the labour market. Modeling 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 respond 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 percent of economic activity. Timeliness and effectiveness of such measures in the long term will allow 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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