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HYSTERESIS, STRUCTURAL SHOCKS AND COMMON TRENDS IN LABOR MARKET: CONSEQUENCE FOR UKRAINE

This article provides an econometric analysis of the effects of technology shocks, labor demand shocks, labor supply shocks and wages shocks on the labor market in Ukraine. Structural vector autoregressive error correction model is formed on macroeconomic data for 2002-2014. The presence of hysteresis in unemployment is revealed. Three common trends are defined which determine the behavior of labor productivity, employment, unemployment rate and real wages. It is shown that only technological shocks have a positive long-term impact on productivity, although in the short run positive changes can be caused by positive shocks of wages and labor supply. The unemployment rate in the long run significantly reduces due to technological shocks and demand shocks, while supply shocks lead to its growth. Technological shocks and labor demand shocks are the source of positive change in the number of employed and real wages.
JEL: C30; E24

1. Introduction

Worsening of general macroeconomic situation in Ukraine leads to conflict aggravation in a social-labor sphere. These contradictions are intensified by absence of effective structural changes in employment, narrowing of job opportunities, incomplete employment of labor force and decline of real income from employment. The current state of the domestic labor market is characterized by professional qualification imbalances of labor demand and supply, high level of unemployment, the mismatch between the sectorial structure of employment and necessities of innovative economy development, high level of low-productivity informal employment. At the same time, there is a change of priorities and values in a socio-economic sphere. A domestic labor market gradually adopts global trends, labor market flexibilityacquires new qualities in its various forms and displays. However, it is necessary to take into account that in the conditions of world economy globalization exogenous factors and shocks strengthen influence on forming and realization of state economic policy. The reaction on these factors and shocks can be both permanent and temporary due to inertia of labor market and hysteresis of unemployment.

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More and more publications devoted to the problems of employment appear in Ukrainian scientific literature. Scientists examine theoretical aspects of the labor market, give its general characteristics, point to quantitative and qualitative parameters, consider the features of regional labor markets and study the structural changes in the economic system. In particular, Yuryk and Konovalov (2014) analyze tendencies and peculiarities of Ukrainian labor market development, discover and systematize its problems and contradictions, point to the necessity to overcome major employment disparities to motivate and stimulate economic activity. Grynevych and Zirko (2014) examine the intensity of structural changes in investment and employment in various economy sectors basing on the method of structural and dynamic analysis. Pryimak and Skorupka (2013) pay regard to the necessity of integral indexes application and describe existing methods of statistical analysis and modeling of processes in the labor market.A number of researches, among others Lisogor (2012), Matviyishyn (2012) emphasize the importance of planning measures to regulate the labor market, to take into account the forecasting results of population age structure and trends of labor market development. Ukrainian authors state that the mechanism of labor market regulationin Ukraine should combine financial, structural investment, organizational, social and economic management components and should be implemented in the context of economic reforms policy (Yuryk and Konovalov**,** 2014). They also indicate the application necessity of the world experience in the labor market management in Ukraine (Kovalchuk, 2014).

Foreign scientists analyze and study labor markets of different countries basing on the research of vector dynamic econometric models. In particular, Jacobson, Vredin and Warne (1997) estimate a structural vector autoregressive model with common trends and analyze the factors of hysteresis in unemployment in Norway, Denmark and Sweden. Carstensen and Hansen (2001) analyze the labor market in West Germany using vector error correction model. Moravanský and Němec (2006) estimate the parameters of wage bargaining model and conduct the analysis of hysteresis in unemployment in Czech Republic on the basis of macroeconomic data of the labor market. Huang (2011) analyzes panel data of unemployment rate series for the countries of OECD, conducts modeling of their fluctuations around equilibrium rate and confirm the hypothesis of hysteresis. Dritsaki and Dritsaki (2013) reveal the presence of hysteresis in unemployment in three countries of the European Union (in Greece, Ireland and Portugal). Baffoe-Bonnie and Gyapong (2012) use structural VAR model to study the wages changes impact on the dynamics of labor productivity, employment and prices in agricultural and industrial sectors in the short and the long run. Dupaigne and Feve (2009) study the effect of technological shocks on labor demand, employment and productivity in the G-7 countries. Blanchard and Galí (2010) build the utility-based model of fluctuations and show that the trade-off between inflation and unemployment depends on labor market characteristics. Ravn and Simonelli (2008) use 12-dimensional VAR model to study the influence of structural technology and monetary policy shocks on volatility of labor market in the USA. Mandelman and Zanetti (2014) basing on the real business cycle model demonstrate that positive technological shocks lead to the decline in labor inputs.

The aim of this article is the empiric analysis and econometric modeling of structural relationships between labor productivity, employment, unemployment rate and real wages in Ukraine, which enables to measure the effects of technological shocks, labor demand and labor supply shocks on processes taking place in social labor sphere of national economy.

2. Theoretical Background and Data

The modification of macroeconomic labor market model (Jacobson, Vredin and Warne, 1997) serve as a theoretical basis of empirical modeling

$$rgdp_t = \rho \cdot empl_t + \theta_t, \quad (1)$$

$$\theta_t = \theta_{t-1} + \varepsilon_t^{technology}, \quad (2)$$

$$empl_t = -\eta \cdot rwage_t + \lambda \cdot rgdp_t + \zeta_t, \quad (3)$$

$$\zeta_t = \varphi \cdot \zeta_{t-1} + \varepsilon_t^{demand}, \quad (4)$$

$$lf_t = \pi \cdot rwage_t + \xi_t, \quad (5)$$

$$\xi_t = \xi_{t-1} + \varepsilon_t^{supply}, \quad (6)$$

$$rwage_t = \delta \cdot (rgdp_t - empl_t) + \kappa \cdot empl_t - \gamma \cdot (lf_t - empl_t) + \varsigma_t \quad (7)$$

$$\varsigma_t = \psi \cdot \varsigma_{t-1} + \varepsilon_t^{rwage}, \quad (8)$$

where *rgdp* = log *RGDP*, *empl* = log *EMPL*, *lf* = log *LF*, *wage* = log *WAGE*, *p* = log *PRICE*, *rwage* =*wage*–*p* denote the time series of natural logarithms of real gross domestic product, the number of employed in the economy, labor force, average nominal wages, prices and real wages respectively. Variables θ_t, ζ_t, ξ_t, ς_t define stochastic technology trend, random disturbance of labor demand, exo enous stochastic trend of labor supply and stochastic trend of wages, and $\varepsilon_t^{technology}$, ε_t^{demand}, ε_t^{supply}, ε_t^{rwage} – are pure technology shock, labor demand shock, labor supply shock and wage shock respectively.

Equation (7) can describe non-Walrasian character of labor market and enables to determine the degree of its competitiveness. Changes in the value ς_t can be interpreted as a reflection of changes in equilibrium unemployment rate. Defining these values as $u_t^* = \varsigma_t/\gamma$, equation (7) can be rewritten as

$$rwage_t = \delta \cdot (rgdp_t - empl_t) + \kappa \cdot empl_t - \gamma \cdot \left[(lf_t - empl_t) - u_t^*\right], \quad (9)$$

which shows that real wage reacts to deviations of unemployment from its equilibrium level. Then the shock ε_t^{rwage} can also be interpreted as a shock of equilibrium unemployment rate, while ψ parameter specifies inflexibility of the labor market.

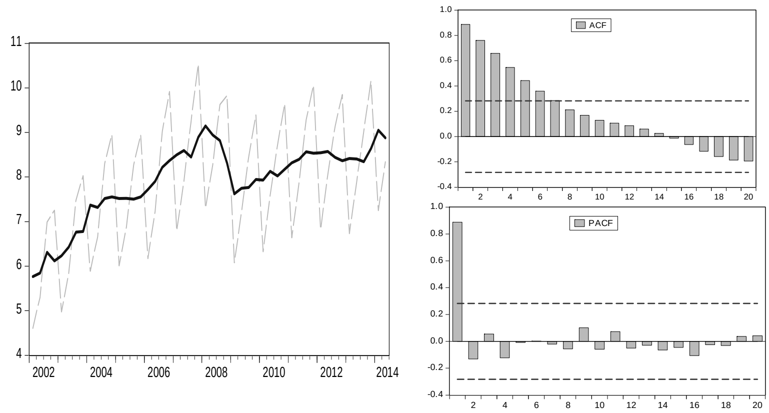
We use quarterly data of the State Statistics Service of Ukraine for the period from the first quarter of 2002 to the second quarter of 2014 for empirical modeling of relationships between Ukrainian labor market indicators. Labor productivity series are defined as $prod_t$ = log $PROD_t$ = log $(RGDP_t/EMPL_t)$ = $rgdp_t - empl_t$ and unemployment rate as $UR_t = lf_t - empl_t$. We adjust all the series on seasonality (using Censusx12 method) and deterministic shifts.

Figures 1–4 shows the behavior of labor productivity, the number of employed, unemployment rate and real wages, dynamics of their seasonally adjusted values and first differences of logarithms series together with the values of autocorrelation (ACF) and partial autocorrelation (PACF) functions.

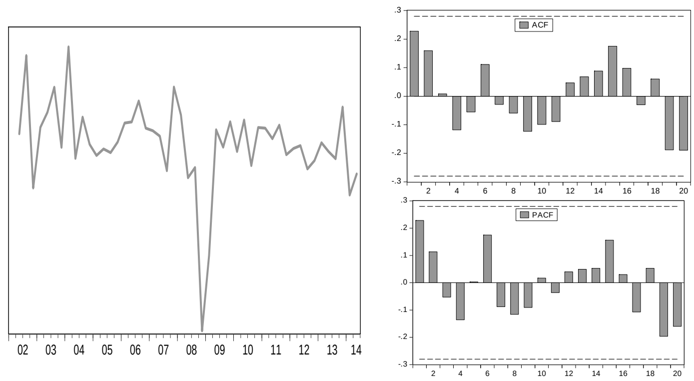
Figure 1

Dynamics of:

a) labor productivity and its seasonally adjusted series



b) first differences of series log $PROD_t = rgdp_t - empl_t$

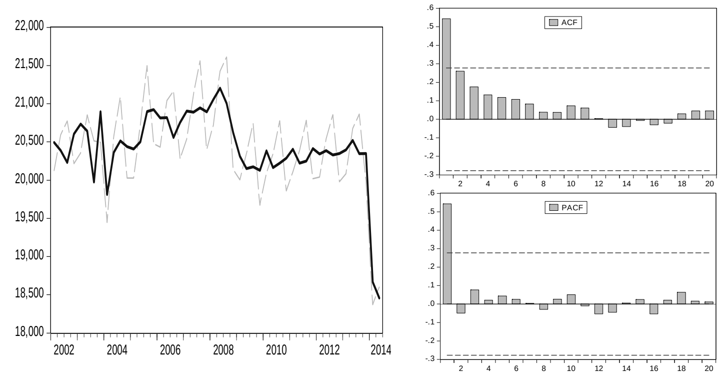


Source: authors' elaboration based on State Statistics Service of Ukraine Database.

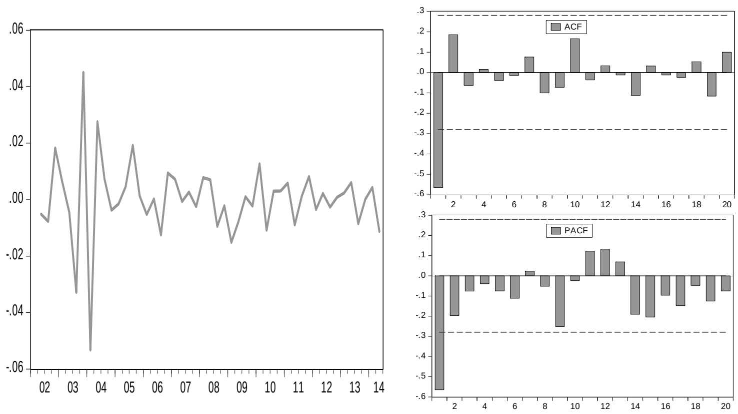
Figure 2

Dynamics of:

a) a number of employed and its seasonally adjusted series



b) first differences of series log $EMPL_t = empl_t$

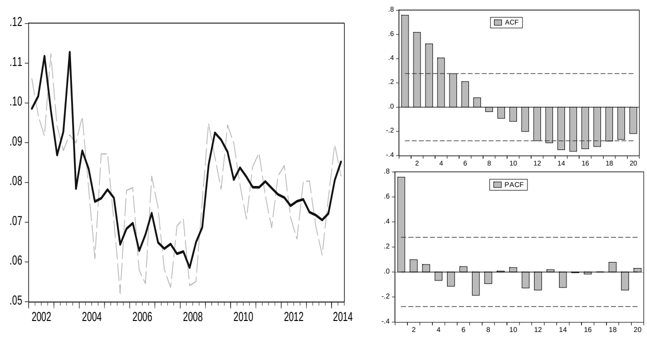


Source: authors' elaboration based on State Statistics Service of Ukraine Database.

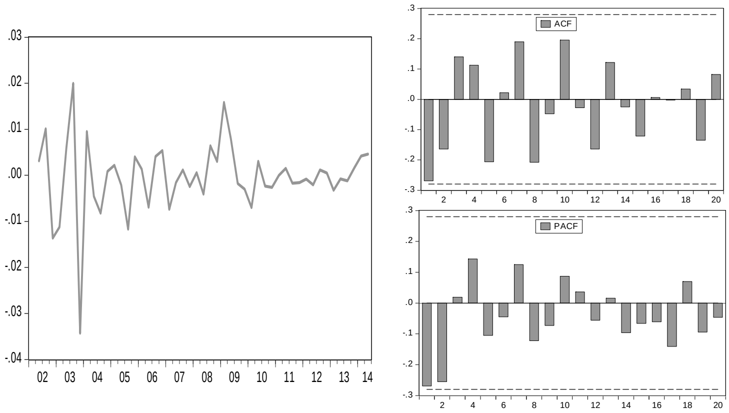
Figure 3

Dynamics of:

a) unemployment rate and and its seasonally adjusted series



b) first differences of series log UR_t

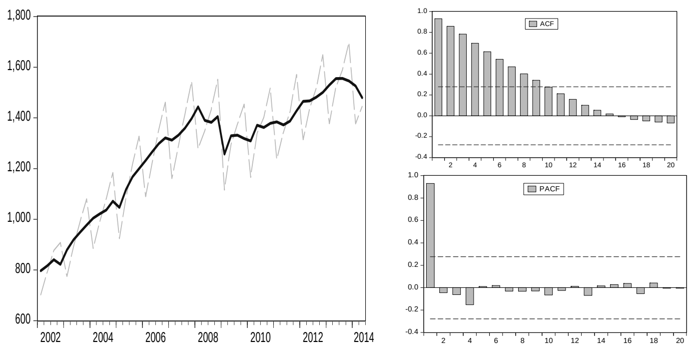


Source: authors' elaboration based on State Statistics Service of Ukraine Database.

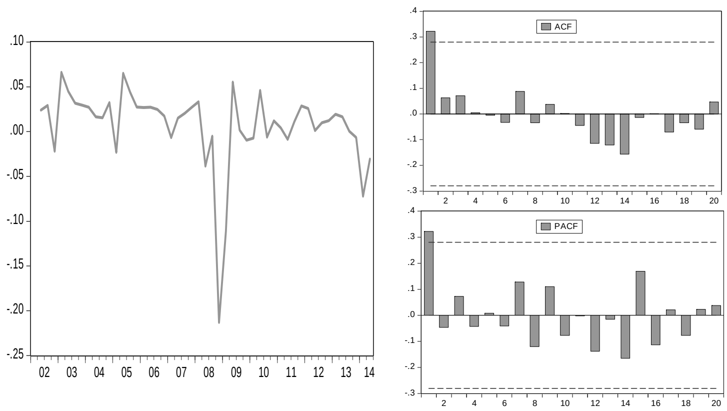
Figure 4

Dynamics of:

a) real wages $RWAGE_t$ and its seasonally adjusted series



b) first differences of series log $RWAGE_t = rwage_t$



Source: authors' elaboration based on State Statistics Service of Ukraine Database.

We transform the model (1)–(8) into the model concerning variables of labor productivity $prod_t$, employment $empl_t$, unemployment rate UR_t and real wages $rwage_t$ and write it in a matrix form

$$\boldsymbol{D}\, \boldsymbol{y}_t = \boldsymbol{\omega}_t, \tag{10}$$

where $\boldsymbol{y}_t = (prod_t, empl_t, UR_t, rwage_t)'$ is the vector of endogenous variables, $\boldsymbol{\omega}_t = (\theta_t, \zeta_t, \xi_t, \varsigma_t)$ is a vector of disturbances. If determinant of ***D***, which is

$\Delta = (1 - \rho\lambda)(1 + \gamma\pi) + \eta(\gamma - \kappa) + (\rho - 1)\eta\delta$,

does not equal a zero, then solving the model (10) we obtain

$$\begin{pmatrix} rgdp_t - empl_t \\ empl_t \\ lf_t - empl_t \\ rwage_t \end{pmatrix} = \frac{1}{\Delta}\begin{pmatrix} \eta(\gamma-\kappa) + (1-\lambda)(1+\gamma\pi) \\ \lambda(1+\gamma\pi) - \eta\delta \\ \eta\delta - \lambda(1+\kappa\pi) + \pi\delta(1-\lambda) \\ \lambda(\gamma-\kappa) + \delta(1-\lambda) \end{pmatrix}\theta_t + \frac{1}{\Delta}\begin{pmatrix} (\rho-1)(1+\gamma\pi) \\ 1+\gamma\pi \\ \delta\pi(\rho-1) - 1 - \kappa\pi \\ \gamma - \kappa - \delta(1-\rho) \end{pmatrix}\zeta_t +$$

$$+\frac{1}{\Delta}\begin{pmatrix} (\rho-1)\eta\gamma \\ \eta\gamma \\ 1-\rho\lambda-\kappa\eta+\delta\eta(\rho-1) \\ \gamma(\rho\lambda-1) \end{pmatrix}\xi_t + \frac{1}{\Delta}\begin{pmatrix} \eta(1-\rho) \\ -\eta \\ \eta+\pi(1-\rho\lambda) \\ 1-\rho\lambda \end{pmatrix}\varsigma_t . \tag{11}$$

3. Empirical Model

We conduct econometric analysis of labor market model basing on unconstrained vector autoregressive model which contains p lags

$\boldsymbol{A}(L)\, \boldsymbol{y}_t = \boldsymbol{u}_t$,

or

$$\boldsymbol{y}_t = \boldsymbol{A}_1 \boldsymbol{y}_{t-1} + \ldots + \boldsymbol{A}_p \boldsymbol{y}_{t-p} + \boldsymbol{u}_t, \tag{12}$$

where $\boldsymbol{y}_t = (y_{1t}, \ldots, y_{nt})'$ – is a $(n\times1)$-vector of endogenous variables, $\boldsymbol{A}_j$ (j=1,…p) –are $(n\times n)$-matrices. Equation (12) is a reduced form of structural vector autoregressive model

$\boldsymbol{A}\, \boldsymbol{y}_t = \boldsymbol{A}_1^* \boldsymbol{y}_{t-1} + \ldots + \boldsymbol{A}_p^* \boldsymbol{y}_{t-p} + \boldsymbol{B}\, \boldsymbol{\varepsilon}_t$,

where ***A*** and ***B*** are structural form parameter matrices, $\boldsymbol{A}_j = \boldsymbol{A}^{-1}\boldsymbol{A}_j^*$ (j=1,…,p), and the vector of reduced form disturbances $\boldsymbol{u}_t$ is related to the vector of structural shocks by relation

$\boldsymbol{A}\, \boldsymbol{u}_t = \boldsymbol{B}\, \boldsymbol{\varepsilon}_t$.

Therefore, we distinguish three types of random variables: $\boldsymbol{v}_t = \boldsymbol{B}\, \boldsymbol{\varepsilon}_t$ is $(n\times1)$- vector of structural errors; $\boldsymbol{u}_t = \boldsymbol{A}^{-1}\, \boldsymbol{B}\, \boldsymbol{\varepsilon}_t = K\, \boldsymbol{\varepsilon}_t$ are residuals of reduced VAR model which are described by the process of white noise with zero mean and constant covariance matrix $\boldsymbol{\Sigma_u}$; $\boldsymbol{\varepsilon_t}$ are structural shocks or structural innovations which are assumed to be orthogonal. Structural shocks in further econometric modeling in the equations of productivity, employment, unemployment and real wageare associated as technology shocks, labor demand shocks, labor supply shocks and wage-setting shocks respectively, that is $\boldsymbol{\varepsilon_t} = (\varepsilon_t^{technology}, \varepsilon_t^{demand}, \varepsilon_t^{supply}, \varepsilon_t^{rwage})'$.

The choice of the correct specification of unrestricted VAR model that is a basis for error correction model is an important step of empirical analysis in the process of constructing adequate structural dynamic labor market model. We select the lag length of endogenous variables p included in VAR model basing on sequence analysis of likelihood ratio LR modified statistic, comparison of prediction errors FPE, multivariate generalization of Akaike, Schwarz and Hannan-Quinn information criteria. We select maximum lag length p_{max}=5 taking into account the acceptable number of observations. We estimate corresponding VAR model and conduct a series of necessary diagnostic tests for all the variants. In particular, we test the presence of autocorrelation, normality distribution and heteroskedasticity of residuals in the VAR models. The tests results for different lengths of model (p = 1, …, 5) are shown in Table 1.

Table 1

Results of VAR Model Length Evaluation

Statistic	Lag length					
	0	1	2	3	4	5
AIC	-20.496	-23.681	**-24.158***	-24.039	-24.131	-24.111
SIC	-19.701	**-22.250***	-22.091	-21.336	-20.792	-20.196
HQ	-20.198	-23.145	**-23.384***	-23.027	-22.880	-22.714
LM(1)	97.8419 [0.0000]	28.1730 [0.0301]	36.4458 [0.0025]	44.5690 [0.0002]	**20.9117** [0.1819]	28.1511 [0.0303]
LM(5)	35.5038 [0.0034]	**17.5566** [0.3505]	**16.3730** [0.4272]	**16.4303** [0.4234]	**11.3488** [0.7875]	30.4309 [0.0159]
Port.Test[5]	152.3927 [0.0001]	78.8915 [0.0035]	66.0011 [0.0223]	**67.3953** [0.2677]	**72.8229** [0.6137]	112.3327 [0.0000]
Q_skewness	44.8098 [0.0000]	8.6978 [0.0691]	**4.7419** [0.3148]	**1.6113** [0.8067]	**4.4470** [0.3489]	**1.9982** [0.7361]
Q_kurtosis	94.1076 [0.0000]	35.2595 [0.0000]	**6.2408** [0.1819]	**2.3893** [0.6645]	**7.7448** [0.1014]	**0.3171** [0.9887]
Heteroskedasticity Tests	87.5937 [0.0008]	**105.2451** [0.9455]	266.7212 [0.0049]	336.4206 [0.0314]	**389.2758** [0.2354]	—

Source: authors' evaluation.

According to test results, VAR(1) model which can be selected according to SIC criteria reveals the signs of residuals autocorrelation and reject normality distribution, while VAR(2) model specified by AIC and HQ criteria is characterized by presence of heteroskedasticity and serial correlation. Therefore VAR models with lag length p = 1 та p = 2 are too restrictive specifications for labor market modeling. We continue the analysis with the use of VAR(4) model due to the fact that with $p = 4$ none of the diagnostic tests proves misspecification.

The investigation of time series stationarity $prod_t$, $empl_t$, UR_t, $rwage_t$ by means of augmented Dickey-Fuller unit root test shows their first order integration. Integration of unemployment series confirms the hypothesis of hysteresis, which is associated with the presence of constant component in unemployment series described by the process of random walk.

We use VAR(4) specification and analyze cointegration relationships which contain different deterministic terms (constant and linear trend). We base the findings of cointegrating rank on Johansen cointegration tests (maximum eigenvalue statistics and trace statistics). Firstly we consider null hypothesis about absence of cointegration relations (r=0) against the alternative of the existence of at least one cointegratiion vector (r≥1). Further, we test the null hypothesis about the existence of at the most one cointegration vector (r≤1) against the alternative that there are at least two cointegration vectors (r≥2) etc. The results of the Johansen tests (Table 2) indicate cointegrating rank r=1.

Table 2

The Results of Cointegration Tests (cointegration relationship includes linear trend)

Hypothesis	Trace – statistics			λ-max – statistics			Eigenvalues
	LR	95% critical values	p-values	LR	95% critical values	p-values	
H_0: $r = 0$	93.07**	63.87	0.0000	53.47**	32.11	0.0000	0.6952
H_0: $r \leq 1$	39.59	42.91	0.1033	23.31	25.82	0.1036	0.4043
H_0: $r \leq 2$	16.28	25.87	0.4701	12.38	19.38	0.3803	0.2405
H_0: $r \leq 3$	3.89	12.51	0.7567	3.89	12.51	0.7567	0.0829

Source: authors' evaluation.

Since labor market indexes under test are cointegrtaing, the correct method of modeling their behavior is a vector error correction model, which generally has the form

$$\Delta \boldsymbol{y}_t = \boldsymbol{\Pi}\, \boldsymbol{y}_{t-1} + \boldsymbol{\Gamma}_1 \Delta \boldsymbol{y}_{t-1} + \ldots + \boldsymbol{\Gamma}_{p-1} \Delta \boldsymbol{y}_{t-p+1} + \boldsymbol{K}\, \boldsymbol{\varepsilon}_t\,, \qquad (13)$$

where $\Delta \boldsymbol{y}_t = \boldsymbol{y}_t - \boldsymbol{y}_{t-1}$, matrix $\boldsymbol{\Pi} = -\left(\boldsymbol{I}_n - \sum_{j=1}^{p} \boldsymbol{A}_j\right)$ defines long term relationship between variables and matrices $\boldsymbol{\Gamma}_s = -\sum_{j=s+1}^{p} \boldsymbol{A}_j$, $(s = 1,\ldots,p-1)$ characterize dynamics of their short term behavior, $\boldsymbol{\varepsilon}_t \sim (\boldsymbol{0}, \boldsymbol{I}_n)$. If exists r cointegration relationships then VEC model (13) can be written as

$$\Delta \boldsymbol{y}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\, \boldsymbol{y}_{t-1} + \boldsymbol{\Gamma}_1 \Delta \boldsymbol{y}_{t-1} + \ldots + \boldsymbol{\Gamma}_{p-1} \Delta \boldsymbol{y}_{t-p+1} + \boldsymbol{K}\, \boldsymbol{\varepsilon}_t, \qquad (14)$$

where $\boldsymbol{\beta}$ – cointegartion vector, $\boldsymbol{\alpha}$ – the loading matrix. Matrix $\boldsymbol{\alpha}$ determines adjustment coefficients and interprets as adaptation rate to long-term cointegrating relationships.

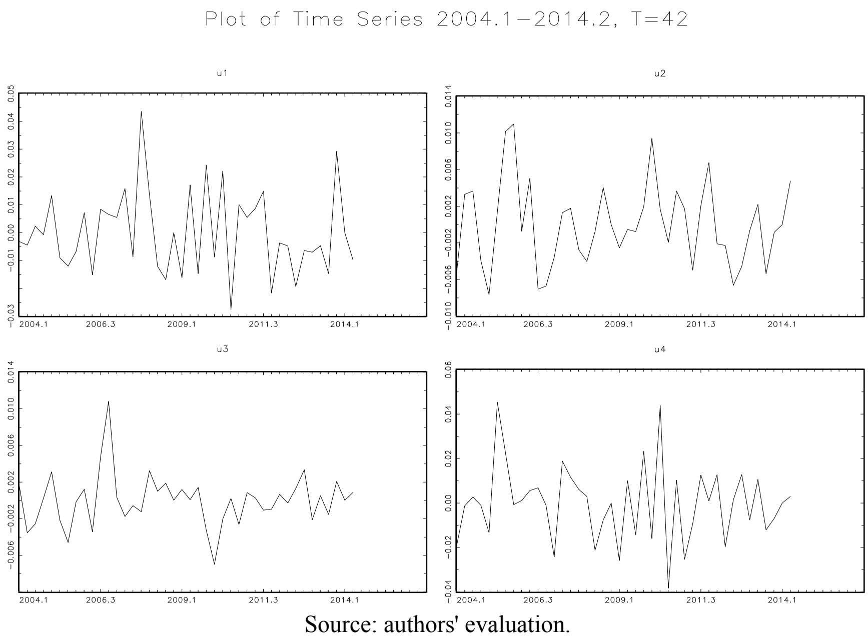
In the model (14) the growth rates of labor productivity, employment, unemployment rate and real wages are connected by relationships of their previous values and previous deviations from long term equilibrium cointegration relationships. Structural shocks $\boldsymbol{\varepsilon}_t$ = ($\varepsilon_t^{technology}$, ε_t^{demand}, ε_t^{suplly}, ε_t^{rwage})' are important elements of SVAR models. However, they are not forecasted by means of previous process characteristics and they are input elements in the linear dynamic relations system, which generates four-dimension vector time series $\boldsymbol{y}_t$.

We examine the estimated model residuals by means of testing multivariate normality assumptions, which are the basis for the methodology of VAR estimation model. If the residuals are autocorrelated, heteroskedastystic, their distribution is asymmetric or characterized by biased kurtosis, then VECM estimations can not be considered as evaluations, which correspond to the method of maximum probability of complete information (FIML), and therefore they may not have optimal properties. In such cases, the obtained estimation parameters may not have any sense, and since we do not know their real properties, the modeling findings may be incorrect.

We conduct initial verification of specifications correctness basing on graphic residuals analysis that often makes it possible to identify specifications problems that are not available through tests. Figure 5 shows the dynamics of estimated residuals series of each model equation.

Figure 5

Dynamics of estimated SVEC model residuals.



Source: authors' evaluation.

Figure 5 shows good behavior of residuals but graphic analysis is only necessary instruments to identify problems in model specifications and can not replace test procedure. Therefore, we test the presence of autocorrelation in a series of estimated SVEC model residuals. We verify the null hypothesis about the absence of ARCH effects in residuals and test normality of their distribution. The results of the tests given in Table 3 reject residuals autocorrelation, indicate normality of their distribution and lack of conditional heteroskedasticity and therefore the adequacy of the model.

Table 3

Results of VEC Model Residuals Diagnostics

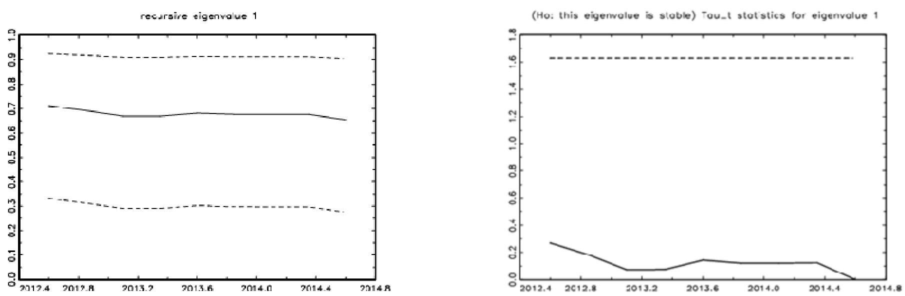
ARCH-LM тест (16 lags)					
Equation		χ^2 - statistic	*p* - value	*F* - statistic	*p* - value
prod		13.5444	0.6326	2.0591	0.1905
empl		11.1602	0.7995	1.3550	0.3732
UR		16.9358	0.3898	4.0146	0.0474
rwage		10.0497	0.8640	1.1155	0.4792
Nonnormality Tests					
Equation		Skewness	Kurtosis	Jarque–Bera Test	*p* - value
prod		-0.4644	3.4485	1.7287	0.4213
empl		-0.4398	2.8739	1.2828	0.5265
UR		0.0753	4.3326	2.9225	0.2319
rwage		-0.0061	2.6070	0.2512	0.8820
Multivariate Statistics					
VARCH-LM Test Statistic (3 lags)		Multiple Skewness Test		Multiple Kurtosis Test	
χ^2- statistic	*p* - value	χ^2- statistic	*p* - value	χ^2 - statistic	*p* - value
312.2194	0.3018	4.8158	0.3067	3.1508	0.5329

Source: authors' evaluation.

Figure 6 shows a recursive eigenvalues and corresponding values of τ-statistics (Lutkepohl and Kratzig, 2004) to test the stability of the model parameters. It can be confirmed that the SVEC model is an adequate description of the processes dynamics on the labor market since they do not give reason to doubt instability of the model, and diagnostic tests for VECM do not indicate misspecification.

Figure 6

Recursive eigenvalues (*a*) and τ-test (*b*) with 5% critical value



a *b*

Source: authors' evaluation

We analyze the dynamic effects of structural shocks on productivity, employment, unemployment and real wages using SVEC model. Impulse analysis is conducted basing on the moving average representation (Lutkepohl and Kratzig, 2004)

$$\boldsymbol{y_t} = \boldsymbol{\Psi} \sum_{i=1}^{t} \boldsymbol{u_t} + \boldsymbol{\Phi}(L)\, \boldsymbol{u_t} + \boldsymbol{y_0}\,, \tag{15}$$

where $\boldsymbol{\Psi} = \boldsymbol{\beta}_\perp(\boldsymbol{\alpha}'_\perp(\mathbf{I}_n - \sum_{i=1}^{p-1} \boldsymbol{\Gamma_i})\boldsymbol{\beta}_\perp)^{-1}\boldsymbol{\alpha}'_\perp$ – long-term effects matrix; the matrices $\boldsymbol{\beta}_\perp$, $\boldsymbol{\alpha}_\perp$ denote the orthogonal complements to $\boldsymbol{\beta}$, $\boldsymbol{\alpha}$; $\boldsymbol{\Phi}(L) = \sum_{j=0}^{\infty} \boldsymbol{\Phi_j} L^j$; matrices $\boldsymbol{\Phi_j}$ determine transitory effects. We should note that the rank of $\boldsymbol{\Psi}$ is $n - r$, where r – cointegrating rank of the system. Orthogonal decomposition into components is used in order to investigate the dynamic impact of each shock and it is suggested that the structural shocks are mutually uncorrelated and therefore orthogonal. So we assume

$$\boldsymbol{\Sigma_\varepsilon} = \mathrm{E}[\boldsymbol{\varepsilon_t}\, \boldsymbol{\varepsilon'_t}] = \boldsymbol{K}^{-1} \boldsymbol{\Sigma_u}\, (\boldsymbol{K}^{-1})' = \boldsymbol{I_N}\,, \tag{16}$$

$$\boldsymbol{\Omega} = \boldsymbol{\Psi}\, \boldsymbol{K} = [\boldsymbol{M}_{n\times k}\; \boldsymbol{O}_{n\times r}]. \tag{17}$$

Condition (16) defines independence of structural shocks and is standard condition of orthogonalization. The matrix $\boldsymbol{K}$ is undefined and needs estimation. The assumption (17) implies that only the first $k = n - r$ structural shocks have a permanent effect, while the remaining r shocks have only a transitory impact. We can obtain matrix $\boldsymbol{M}$ and $\boldsymbol{R^*}$ and rewrite VMA (15) as a model of common trends using cointegration constraints and orthogonality of permanent and temporary shocks

$$\boldsymbol{y_t} = \boldsymbol{M}\, \boldsymbol{\tau_t} + \boldsymbol{R^*}(L)\, \boldsymbol{\varepsilon_t} + \boldsymbol{y_0}\,,$$

with k-dimensional structural random walk or general trend

$$\boldsymbol{\tau_t} = \boldsymbol{\tau_{t-1}} + \boldsymbol{v}_t$$

and stationary structural polynomial $\boldsymbol{R^*}(z)$. Conditions (16), (17) are not sufficient to determine the matrix $\boldsymbol{K}$ and we additionally need $k(k\text{-}1)/2$ economic restrictions to determine general trends and $r(r\text{-}1)/2$ restrictions to determine r transitory shocks respectively. They constitute together $kr + k(k\text{-}1)/2 + r(r\text{-}1)/2 = n(n\text{-}1)/2$ restrictions. In the case of structural SVEC model $\boldsymbol{u_t} = \boldsymbol{A}^{-1}\boldsymbol{B}\boldsymbol{\varepsilon_t}$, therefore orthogonal short term impulse response is obtained from $\boldsymbol{\Phi_j}\, \boldsymbol{A}^{-1}\boldsymbol{B}$, and long-term shocks effects are defined by matrix $\boldsymbol{\Omega} = \boldsymbol{\Psi}\, \boldsymbol{A}^{-1}\boldsymbol{B}$. This matrix has rank $n\text{–}r$ because rank $\boldsymbol{\Psi} = n\text{-}k$, $\boldsymbol{A}$ and $\boldsymbol{B}$ are nonsingular. Thus, the matrix (17) can have no more than r zero columns and with given reduced matrix rank, each zero column displays only k independent constraints. Thus, if there r transitory shocks zero columns correspond to only kr independent restrictions. Therefore, there is the need to impose $k(k\text{-}1)/2$ additional restrictions in order to exactly determine permanent shocks, and correspondingly $r(r\text{-}1)/2$ additional restrictions to identify transitory shocks (Lutkepohl and Kratzig, 2004).

Structural analysis of the labor market is conducted basing on estimated VEC model (14). Conducted cointegration analysis showes that the system contains k = 3 shocks with permanent effects in VECM and therefore r = 1 shock that has a transitory effect. Therefore, the complete identification of labor market model should apply six linearly independent restrictions, given that $\boldsymbol{A}$ is the identity matrix.

Various scientific studies propose different identification schemes of the labor market model. In particular, it is assumed that in the long run labor force is exogenous, i.e. $\pi = 0$. This constraint according to (11) would mean that the behavior of the labor force is specified only by labor supply trend. Bean (1992) proposes restriction $\rho = 1$, which with two general trends provides complete system identification, and if there are three stochastic trends, we need additional assumptions to achieve the identification. Restriction $\lambda = \eta = \delta = 1$ (condition of Layard, Nickell, 1986) in the case of three stochastic trends imposes only two constraints on the trend coefficients and provides identification of equilibrium unemployment trend, since only it has a long term effect on the unemployment level. Thus, technologyl trend and the labor supply trend are not defined and therefore additional restrictions are needed. Assumption $\lambda\rho = 1$ used in Jacobson, Vredin and Warne (1997), can in particular verify whether the labor market is characterized by labor supply exogeneity ($\pi = 0$) and whether the level of unemployment in the long run depends on the labor supply and technology.

Estimated cointegration relationship is consistent with the wage equation, so its stationarity means that wage shocks have no long-term impact on $\boldsymbol{y}_t$. If $\boldsymbol{A} = \boldsymbol{I}_n$, then these findings correspond to the last zero column of the matrix of long-term effects $\boldsymbol{\Omega}$. However, given the matrix rank $\boldsymbol{\Omega}$, these conditions determine only kr = 3 linearly independent restrictions. We should also apply $k(k-1)/2 = 3$ additional restrictions to determine k = 3 permanent shocks. Assuming constant scale effect $\rho = 1$, we find that in the long run labor productivity behavior is specified only by technology shocks $\varepsilon_t^{technology}$. This constraint can be taken into account when putting $(\boldsymbol{\Omega})_{1j}$ (with j = 2,3,4 to zero. We have only two additional linearly independent restrictions arising from the assumption of constant scale effect, since $(\boldsymbol{\Omega})_{14}=0$ is taken into account in the first set of constraints. Therefore, we need one additional restriction to identify SVECM. We suppose that supply shocks have no long-term impact on real wages, i.e $(\boldsymbol{\Omega})_{43} = 0$. Given restrictions are used to identify permanent shocks. Since previous empirical analysis reveales only one transitory shock, we does not require additional contemporaneous restrictions for its identification. Thus, we consider the following structure of long-run impact matrix

$$\boldsymbol{\Omega} = \begin{pmatrix} * & 0 & 0 & 0 \\ * & * & * & 0 \\ * & * & * & 0 \\ * & * & 0 & 0 \end{pmatrix}$$

As a result of the estimation we obtain

$$\hat{\boldsymbol{B}} = \begin{pmatrix} 0.0110(2.96) & -0.0067(-1.31) & 0.0002(0.10) & 0.0070(2.37) \\ 0.0018(1.98) & 0.0013(1.81) & -0.0017(-1.69) & -0.0036(-2.31) \\ -0.0005(-1.02) & -0.0006(-1.21) & 0.0026(2.89) & 0.0006(1.68) \\ 0.0115(2.49) & 0.0116(1.52) & 0.0000(0.01) & 0.0046(2.04) \end{pmatrix}$$

$$\hat{\boldsymbol{\Omega}} = \begin{pmatrix} 0.0140(3.28) & 0 & 0 & 0 \\ 0.0025(2.67) & 0.0014(1.44) & -0.0004(-2.87) & 0 \\ -0.0014(-1.98) & -0.0015(-2.38) & 0.0015(2.87) & 0 \\ 0.0164(2.05) & 0.0177(1.43) & 0 & 0 \end{pmatrix}$$

$$\boldsymbol{\Sigma_u}*100= \begin{pmatrix} 0.0215 & -0.0014 & 0.0003 & 0.0082 \\ -0.0014 & 0.0021 & -0.0008 & 0.0020 \\ 0.0003 & -0.0008 & 0.0008 & -0.0011 \\ 0.0082 & 0.0020 & -0.0011 & 0.0288 \end{pmatrix}.$$

In parentheses we give bootstrap *t*-values obtained using 200 bootstrap replications. Estimated long-term shocks effects to unemployment are in the third row of matrix $\hat{\boldsymbol{\Omega}}$. According to our estimates in the long run both technology and demand shocks significantly reduce the unemployment rate in Ukraine. It is worth noting that only demand shocks have such impact in the Canadian labor market (Lutkepohl et al., 2004), and it is vice versa for Scandinavian countries, for they have significant impact of technology and labor supply structural shocks (Jacobson et al., 1997). We also test other restrictions on the structural shocks effects. In particular, we check whether the labor supply shocks have long term impact on unemployment, which corresponds to the testing of hypothesis H_0: $(\boldsymbol{\Omega})_{33} = 0$. The corresponding *LR* statistics has $\chi^2[1]$-distribution and is *LR* = 6,07 with *p*-value of 0.014. Thus, the null hypothesis rejects at a significance level of 5%, which indicates the significance of supply shocks. Analyzing *t*-statistics of other parameters we find that technology shocks have a significant impact on all labor market indicators.

4. Results

We can calculate the response of the domestic labor market indexes (impulse responses) to structural shocks using estimates of matrices $\boldsymbol{B}$, $\boldsymbol{\Phi_j}$ and $\boldsymbol{\Omega}$. Impulse responses for SVEC model are functions of not only short-term effects matrices and structural parameters matrices, but also the estimated adjustment coefficients and cointegration relationships parameters.

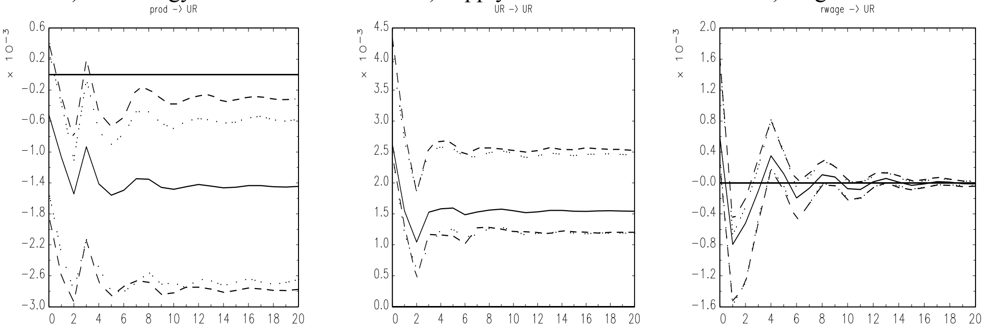
Graphical representation of impulse response functions of developed SVEC model is shown on Fig. 7–8. Confidence intervals are determined basing on Hallbootstrap procedure

(Lutkepohl and Kratzig, 2004). Figure 7 shows the unemployment response to the technology shock, the labor supply shock and wage shock with 95% Hall bootstrap confidence intervals, based on 200 bootstrap replications.

Figure 7

Impulse responses of unemployment to:

a) technology shocks *b*) supply shocks *c*) wage shocks



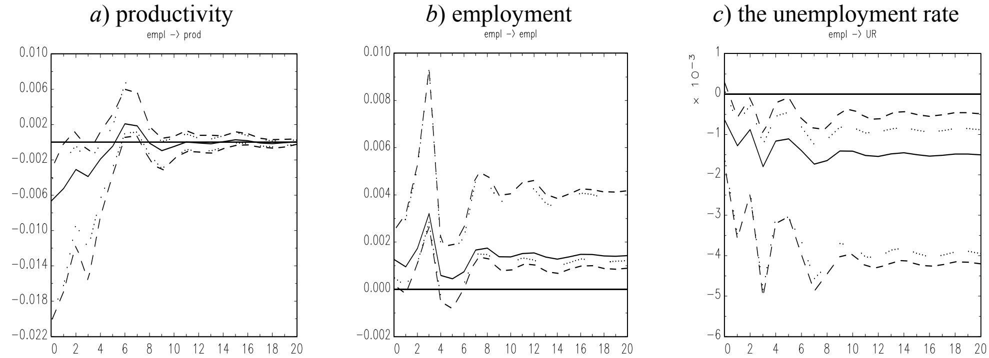
Source: authors' evaluation.

The study of the dynamic impact of technology shock shows that its long-term impact is significant for all variables. In particular, we find that positive technology shock causes a significant increase in productivity, employment and real wages and reduces unemployment (Fig. 7). Moreover, this impact has a significant effect in the short and in the long run. Let us also note that the value of technology shock impactis the greatest for productivity and wages. The sdudies of technology shock impact in Germany (Carstensen and Hansen, 2000) show that unemployment rate does not immediately respond to disturbances in technology, but only after 2-3 quarters. In Norway we have a significantly negative technology shock impact on unemployment, while for Norway and Denmark this impact is not significant (Jacobson et al., 1997).

Figure 8

Impulse response functions to labor demand shocks of:

a) productivity *b*) employment *c*) the unemployment rate



Source: authors' evaluation.

A positive labor demand shock leads to unemployment decrease and significant employment increase (Fig. 8). The maximum effect is achieved in about three quarters, while new long-term rates are reached in about two years after the shock. Modelling results also show that real wages quickly and positively respond to demand disturbances, reaching a new equilibrium level almost after the second quarter. Speaking about the impact of demand shock on labor productivity, we can see only short-term negative impact that lasts 1-2 quarters. In the long run we find that labor demand shocks have no significant effect on productivity. Summing up, we find that due to the demand shock we have long-term positive upward shift of real wages and employment rate, while the unemployment rate significantly decreases. The same result is obtained in the study of the labor market in Germany (Carstensen and Hansen, 2000), but in Norway, Sweden and Denmark temporary labor demand shocks have neither significant short-term effects nor long-term effects (Jacobson et al., 1997).

The functions analysis of impulse response on positive supply disturbances shows that the labor supply positive shock does not have long-term effect on productivity and wages, which is consistent with the bootstrap *t*-values of the long-term effects matrix. Although, in the short run it does not significantly increase productivity for 1-2 quarters. The growth of the labor force immediately leads to higher unemployment, while employment response is not immediate to supply shock. The shock effect on employment is significant only after about six quarters after the shock. It is worth mentioning that labor supply shock in European countries has no significant effect in the long run, although it causes increase in unemployment for about two years.

Response to wage shocks equals zero in the long run. The modelling shows that such shocks have only a minor short-term impact and their effect disappears completely within two years after the shock occurred. It is worth mentioning, however, that positive wage shock in the short run causes a significant increase in productivity, which is felt in the first two quarters. Moreover,we observe fluctuations in employment and unemployment rate within one year after the shock. In particular, the unemployment rate returns to its natural level after the initial increase.

We should say that in Scandinavia wage shock has a long-term impact on the equilibrium unemployment rate, with adjustment to equilibrium unemployment shocks within the next 1-2 years in Norway and Sweden, and for about 4 years in Denmark (Jacobson et al., 1997). Comparing the response values to different shocks, we can say that responses of labor market indexes to wages shocks are small in comparison with the responses to other shocks.

We also calculate forecast error variance decomposition of labor market indexes for different forecasting horizons *h* (Table 4).

The modeling results, in particular, show that wages shocks are the main source of variance in employment changes in the short run, while in the long run for about 70% of the variation is explained by technology shocks and 24% by demand shocks. The variation of productivity in the long run is almost entirely explained by technology shocks where as demand and wages shocks determine 20% of variance in productivity fluctuations for the first two quarters.

Table 4

Forecast Error Variance Decomposition of Productivity and Employment

Forecast horizons	Productivity				Employment			
	$\varepsilon^{technology}$	ε^{demand}	ε^{supply}	ε^{rwage}	$\varepsilon^{technology}$	ε^{demand}	ε^{supply}	ε^{rwage}
1	0.56	0.21	0.00	0.23	0.17	0.08	0.14	0.62
2	0.70	0.15	0.00	0.15	0.32	0.09	0.10	0.49
3	0.75	0.12	0.01	0.11	0.38	0.14	0.08	0.40
4	0.78	0.11	0.01	0.09	0.32	0.31	0.06	0.31
5	0.82	0.09	0.01	0.08	0.39	0.28	0.05	0.27
6	0.85	0.08	0.01	0.07	0.46	0.25	0.05	0.24
7	0.85	0.07	0.01	0.06	0.51	0.22	0.05	0.22
8	0.88	0.07	0.01	0.05	0.53	0.23	0.04	0.19
12	0.92	0.04	0.00	0.04	0.58	0.24	0.04	0.14
16	0.94	0.03	0.00	0.03	0.62	0.24	0.03	0.11
20	0.95	0.03	0.00	0.03	0.64	0.24	0.03	0.09
30	0.97	0.02	0.00	0.02	0.67	0.24	0.03	0.06
40	0.97	0.01	0.00	0.01	0.69	0.24	0.03	0.05

Source: authors' evaluation.

5. Conclusions

Having conducted the empirical analysis based on structural vector autoregressive error correction model for productivity, employment, unemployment and real wages, we found that we have three sources of hysteresis in Ukraine, which are technology shocks, labor demand and labor supply shocks. The results of the econometric analysis show that only technology shocks have long-term positive effects on productivity, although wages and labor supply positive shocks can cause positive changes in productivity in the short run during one quarter. Technology and labor demand shocks cause long-term positive changes in the number of employed, moreover the technology shock impact is twice as strong. Supply shocks cause negative changes in employment, when the shocks impact on employment is some what decelerated and is not felt immediately but only after 2-3 years. The unemployment rate decreases significantly in the long run due to technology shocks and demand shocks, while supply shocks lead to its increase. The change in the equilibrium unemployment rate in the long run, is approximately the same regardless of the type of shock. Wages in the long run react only on technology shocks and labor demand shocks, while wages shocks have only a short-term nature.

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