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# Shocks and rigidities as determinants of CEE labor markets' performance - a panel SVECM approach -

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**Abstract**

In this paper the dynamic responses of labor markets to macroeconomic shocks in eight CEE countries are empirically analyzed in panel SVECM. Identification of shocks, interpreted as real wage, productivity, labor demand and supply shocks, is based on DSGE model with labor market explicitly modeled after Mortensen and Pissarides (1994). Fluctuations in foreign demand are controlled for and the model is estimated with panel procedure, which improves estimation's precision.

We show that propagation of shocks on NMS labor markets fairly resembles that characterizing OECD countries. Productivity improving shocks temporarily increase unemployment. Positive labor demand shocks increase employment, depress unemployment, rise real average wages, and were found to be the main determinant of variability of employment and unemployment in the short-run. In the medium term, in Czech Republic, Latvia, Lithuania and Poland innovations in wages seem to be prevalent drivers of employment and unemployment. The retrospective simulations of the model show that Baltic states and Poland were significantly affected by the collapse of Russian exports in late 1990s, and in 2000 an adverse labor demand shock hit all NMS, except for Hungary and Slovenia. However, the flexibility of wages is found to be crucial factor behind the diverse labor market performance in the region. Slovenia and Estonia fared best when it comes to flexibility of wages on macro level, on the other hand in Czech Republic, Lithuania and Poland downward wage rigidities were especially binding after employment-contracting shocks.

**Keywords:** Unemployment, Rigidities, Transition economies, Cointegration, Structural VECM, Panel econometrics, DSGE models

**JEL Classification Numbers:** C32, E24, E32, J20, J60, P23

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## Introduction

In the last two decades most Central and Eastern European countries managed to transform their centrally planned economies and integrated themselves with global markets and trade system. Particular success was shared by eight post-communist states that in 2004 became new members of European Union (NMS8) - namely Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. In this paper we concentrate on that group.

Specific transition shocks played a principal role in shaping macroeconomic behavior of the CEE region in the early 1990s. With time, however, the relative importance of these disturbances had faded, and regularities characterizing developed free-market economies became dominant. In the mid 1990s business cycle in most NMS8 began to follow a relatively well coordinated pattern of upturns and slowdowns. At the same time, average GDP growth rates as well as the amplitude of macroeconomic fluctuations differed within the region. In 1997-1998 unemployment indicator in NMS8 was 6.5 percent on average, and the difference between the lowest, Czech Republic, and highest unemployment country, Slovakia, was less than 4 percentage points. As soon as two years later, and till 2002, the average exceeded 8 percent and the difference between the lowest, then Hungary, and the highest, then Poland, unemployment country amounted to 10 percentage points. In 2007 the average unemployment was down to 5 percent, and the spread between Lithuania (lowest) and Slovakia (highest) amounted to less than 5 percentage points.

An important question is whether these different evolutions were caused by idiosyncratic disturbances or rather by country specific, possibly institutionally driven ability to quickly and smoothly absorb shocks on the labor market.[1] If the first scenario is true, it was only "bad luck" that unemployment exploded in some CEE countries and did not in others. If, however, ability to absorb shocks cannot be neglected as a source of differences between NMS labor markets, contrasting policy choices could lay in the center of diverse labor market histories in the region.

In this paper we try to empirically address this question. We start with identifying structural shocks on NMS8 labor markets in 1996-2007. In line with the literature, we take into account both supply side - innovations to productivity, labor supply and wages - and demand side - foreign trade fluctuations and internal labor demand - shocks. Using structural vector error correction model (SVECM), we estimate elasticities of main labor market aggregates with respect to these disturbances. Obtained results are used in three ways. Firstly, impulse response and historical variance decomposition

[1] This question was studied for OECD countries by eg. Layard, Nickell, Jackman (1991), Bean (1994), Blanchard, Wolfers (2000), Blanchard (2005), Nickell, Nunziata, Ochel (2005), Bassanini, Duval (2006).

analyzes are performed. Secondly, a range of thought experiments is conducted, to study the impact of certain structural shocks and wage rigidities on historical NMS8 labor market evolutions. Thirdly, three measures of rigidities based on SVECM are presented. They enable us to synthetically asses the potential of CEE economies to adapt to macroeconomic shocks.

Applying SVECM to labor market dynamics constitutes a generalization of SVAR approach initiated by Blanchard and Quah (1989) seminal paper and developed thereafter eg. by Gamber and Joutz (1993) and Dolado and Jimeno (1997), Balmaseda, Dolado and Lopez-Salido (2000). In contrast to these authors, we allow for nonstationarity of modeled variables and estimate a structural VECM with one cointegration relation. We consider a system of four domestic variables - GDP per worker, real wages, employment and unemployment - and control for fluctuations of foreign demand. As far as domestic variables are concerned, analogous models were applied by Jacobson, Vredin and Warne (1997) for three Scandinavian economies, by Breitung, Brüggemann and Lütkepohl (2004) for Canada and or Brüggemann (2006) for Germany. In comparison with these articles, we propose four innovations.

Firstly, our data set covers eight CEE economies. Secondly, the model is estimated with a panel estimator which constitutes a slight modification of Breitung's (2005) two-step method. Thirdly, we explicitly control for fluctuations of external demand from major NMS8 trading partners (CIS and EU15). Foreign variables are included in the model as quasi-exogenous, ie. they are treated as exogenous, but all multiplier experiments can be conducted as if they were endogenous. Fourthly, identifying restrictions which, starting from Jacobson, Vredin and Warne (1993), have been inferred from a multi-equation stylized labor market model, are derived here from a structural Dynamic Stochastic General Equilibrium model.

The paper is organized as follows. Section one introduces DSGE model with non-walrasian labor market. Section two specifies the empirical SVECM, and explains panel estimation strategy. In this section we also analyze dynamic properties of the data. Next, impulse responses and historical variance decompositions are presented. In section four, we conduct retrospective simulations of the model which allow us to pinpoint shocks that drove NMS8 labor markets evolution in 1996-2007 to the greatest extent. We distinguish between original shocks and rigidities, and propose three indices to measure the latter. Final section concludes.

# 1 DSGE model of labor market

## 1.1 Introduction

To quantify and interpret the macroeconomic shocks driving labor markets in CEE economies, we need to establish a set of plausible restrictions, which identify structural disturbances in empirical SVECM. This set should both be based on economic theory and take into account statistical properties of analyzed time series. The theoretical model presented in this section provides us with a catalogue of long-term relations between structural macroeconomic shocks and economic variables. In the next section stationarity and cointegration tests are performed, and then the ultimate set of restrictions on SVECM is chosen.

In this respect we follow *inter alia* Dolado and Jimeno (1997), Jacobson, Vredin and Warne (1997), Balmaseda, Dolado and Lopez-Salido (2000), however, contrary to these authors, we do not use a multi-equation stylized model of labor market, but formulate a structural DSGE model with a non-walrasian labor market module. Establishing long-term restrictions on the basis of comprehensive DSGE model - which guarantees optimal behavior of the economic agents - is methodologically more attractive than traditional *ad-hoc* approach.

There is a direct correspondence between variables and shocks included in theoretical model, and variables and structural disturbances analyzed empirically within SVECM framework. It makes interpretation straightforward and provides a transparent identification of structural shocks in SVECM. Simply, we expect that the long-term response to a given shock in the theoretical model should be reflected in its empirical counterpart.

### 1.2 Structure of the model

The small DSGE model takes the form of a standard, *textbook*, real business cycle model of closed economy, supplemented with a search-and-match labor market block, modeled in a Mortensen and Pissarides (1994) tradition. Thanks to this additional mechanism, disparity between labor supply and demand arises naturally, and one is able to analyze unemployment response to macroeconomic shocks. Below we describe the model economy, display the problems solved by households and firms, present the functioning of the labor market and specify stochastic shocks.

In time $t \geq 0$ the economy is populated by $N_t$ agents who form a representative, infinitely living household (dynasty). This household maximizes, in time $t = 0$, its expected lifetime utility from consumption and leisure, which takes the form

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[ N_t^e u(c_t^e, 1 - h_t^e) + U_t u(c_t^u, 1 - h_t^u) \right]$$

where $N_t^e$ denotes the number of employed, and $U_t = N_t - N_t^e$ - the number of unemployed household members. Population is normalized to one in the steady state, i.e. $N_t = e^{\xi_t^N}$, where $\xi_t^N$ is a labor supply shock, which is equal to zero in the steady state. Consumption levels of employed and unemployed are given by $c_t^e$ and $c_t^u$ respectively, whereas $h_t^e$ and $h_t^u$ denote number of hours devoted to work and job search respectively. Because in empirical

SVECM analysis we consider only variables specified on ,,per worker" or ,,per capita", and none on ,,per hour" basis, we keep both $h_t^e$ and $h_t^u$ fixed.

Household is confronted with the following budget constraint

$$N_t^e c_t^e + U_t c_t^u = N_t^e \times W_t \times h_t^e + \psi \times V_t \times W_t + \Pi_t$$
$$N_t^e = (1-\delta_e) \times N_{t-1}^e + \Phi_t h_{t-1}^u U_t$$

where $W_t$ is an hourly real wage, $\Pi_t$ denotes profits transferred from production sector, and the term $\psi \times V_t \times W_t$ reflects total vacancy cost paid by firms to households in the form of additional salaries for employees' engagement in the recruitment process. Hence, total labor income of a single worker is given by $W_t \times h_t^e + \psi W_t \times \frac{V_t}{N_t}$. Parameter $\delta_e$ denotes the exogenous rate of job destruction, whereas $\Phi_t$ is a probability of finding a job by an unemployed. Household controls the following variables: $h_t^u$, $N_t^e$, $c_t^e$ and $c_t^u$, whereas the intensive labor supply, $h_t^e$, and wages, $W_t$, are negotiated with employers (firms) in the Nash bargaining.

Firms own capital $K_t$ and produce final good $Y_t$ with the standard Cobb-Douglas technology. They maximize the present value, $\Pi_0^A$, of the stream of discounted profits, $\Pi_t$, in the form

$$\Pi_0^A = E_0 \sum_{t=0}^{\infty} \Lambda^t \Pi_t$$

where, $\Lambda^t$, is a standard *pricing kernel* reflecting that households are owners of firms. At $t \geq 0$ each producer sets level of investment $I_t$, extensive labor demand $N_t^d$ and the number of open vacancies $V_t$, being confronted with the budget constraints in the form

$$\Pi_t = P_t e^{\xi_t^Y} \times K_{t-1}^{\alpha} (N_t^d h_t^d)^{1-\alpha} - N_t^d h_t^e W_t - I_t - \psi \times e^{-\xi_t^V} \times V_t \times W_t$$
$$K_t = (1-\delta_k) K_{t-1} + I_t$$
$$N_t^d = (1-\delta_e) \times N_{t-1}^d + \Psi_t V_{t-1}$$

where $\Psi_t$ denotes the probability of filling a vacancy, and $\xi_t^Y$ is a technological shock. Firm must bear the vacancy cost - $\psi \times \frac{V_t}{N_t^d h_t^e} \times N_t^d h_t^e \times W_t$ - which is proportional to the product of the share of new vacancies in the total (measured in hours) jobs in the firm - $\frac{V_t}{N_t^d h_t^e}$ - and the cost of salaries for the workers that are engaged in the recruitment process - $N_t^d h_t^e \times W_t$. In other words, job intermediation is costly. Variable $\xi_t^V$, which is equal to 0 in the steady state, can be interpreted as a labor demand shock. As $\xi_t^V$ increases, the costs of holding opened vacancies falls, which encourages producers to rise the number of offered jobs and labor demand. *Numeraire* is given by the price of the final (consumption and investment) good $P_t$. We fix it to one: $P_t = 1$.

Hours worked are assumed to be fixed. Wages are negotiated between households and firms in a Nash bargaining process. Both parties try to maximize surpluses from the new job contract. Household's surplus is denoted by $\Gamma_t$, whereas firm's by $\Sigma_t$. These parameters measure the increase in total expected utility or profit respectively, that each party shall capture if the contract is set. When maximizing the total surplus both sides take into account the first order conditions, which are implied by their optimization problems, and calculated with respect to (i) job supply $N_t^e$ in case of household, and (ii) job demand $N_t^d$ in case of firms. Being precise, the following optimization problem is solved

$$\max_{W_t}(\Lambda_t^V \lambda_t)^{\xi_t^W}(\Lambda_t^N)^{1-\xi_t^W}$$

subject to

$$\Gamma_t = \frac{\partial E_0 \mathcal{U}_0}{\partial N_t^e}, \qquad \Sigma_t = \frac{\partial E_0 \Pi_0^A}{\partial N_t^d}.$$

where $\Lambda_t^V$, and $\Lambda_t^N$ denote shadow prices (Lagrange multipliers) of employment dynamics for producers and household respectively. Shadow price of consumption $\lambda_t$ recalculates product into utility units. Since the variable $\xi_t^W$ reflects the relative bargaining strength of employees and employers, changes in $\xi_t^W$ can be interpreted as real wage shocks.

Description of the labor market is completed with matching technology in line with Mortensen and Pissarides (1994)

$$M_t = (V_t)^\theta (U_t)^{1-\theta}$$

which relates the number of jobs filled $M_t$ to opened vacancies $V_t$, and total search effort $U_t \times h_t^u$. Parameter $\theta$ controls relative importance of each factor. Variable $M_t$ allows defining the probability of filling a vacancy as $\Psi_t = \frac{M_t}{V_t}$, and the probability of finding a job by the unemployed by $\Phi_t = \frac{M_t}{U_t}$.

The model is closed by specification of stochastic processes, which induce shifts in (i) technology level - $\xi_t^Y$, (ii) extensive labor supply - $\xi_t^N$, (iii) labor demand - $\xi_t^V$, and (iv) wage setting process - $\xi_t^W$. We assume that $\xi_t^X$, for $X \in \{Y, N, V, W\}$, is governed by the AR(1) process

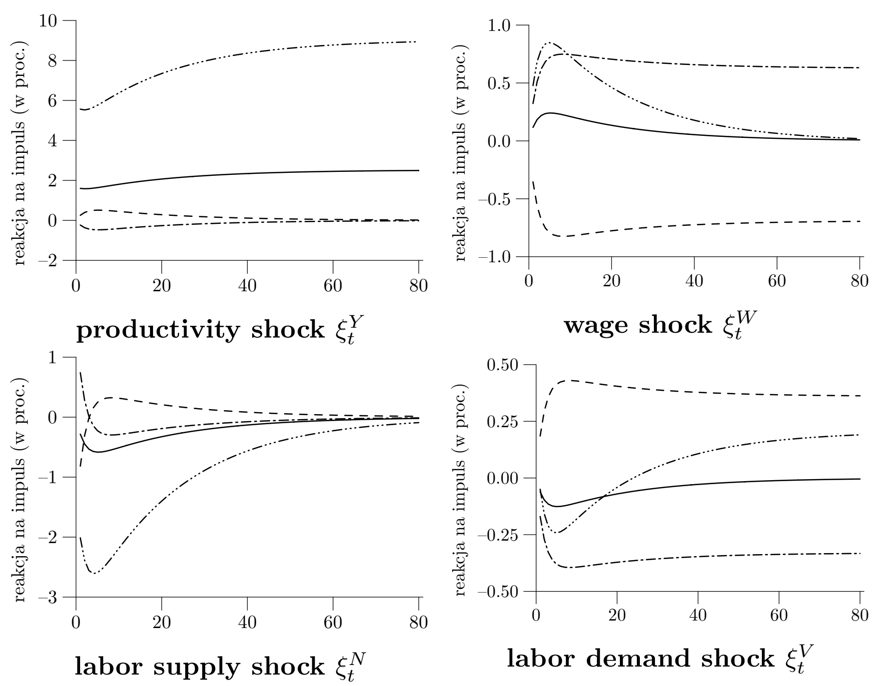
$$\xi_t^X = \rho_X \xi_{t-1}^X + \varepsilon_t^X$$

where orthogonal disturbances $\varepsilon_t^X$ are drawn from normal distributions with mean $\mu_X$, and standard deviation $\sigma_X$. We assume that $\mu_Y = \mu_L = \mu_V = 0$ and $\mu_W = 0.5$. In other words, steady state technology level, labor supply and demand are normalized to one, whereas bargaining power of employees and employers are equal. Such a choice is generic, i.e. other values do not change the long-term properties of the model, which are presented in the next subsection.

## 1.3 Long-term properties of the model

Logarithms of labor productivity, employment rate, unemployment indicator,[2] and real wage per worker are denoted by $lp_t$, $e_t$, $u_t$ and $w_t$ respectively. For each $X \in \{Y, N, V, W\}$ if $|\rho_X|| < 1$, the variables in question returns to its steady state level as the shock is fading away. It is not the case if $\rho_X = 1$. Jacobson, Vredin and Warne (1997) and Balmaseda, Dolado and Lopez-Salido (2000) indicate that the number of long-run restrictions in the SVECM must be coherent with dynamic properties of the data and with the number of cointegrating relations identified in the system. Tests presented in the next section show that all four domestic variables are non-stationary (in the analyzed sample), and suggest existence of exactly one cointegrating relation between them. Therefore, we set $\rho_Y = \rho_L = \rho_V = \rho_W = 1$.

**Figure 1: DSGE model response to permanent structural shocks**




solid line – labor productivity $lp_t$; dashed line – employment rate $e_t$; one-dot line – unemployment indicator $u_t$, three-dots line – real wages $w_t$.

[2] Share of unemployed in total population.

DSGE model responses to permanent shocks are presented on the Figure 1. It can be inferred that in the long run:

- productivity shock $\xi_t^Y$ increases wages $w_t$, and labor productivity $lp_t$, but is neutral for employment $e_t$, and unemployment $u_t$;
- innovation to wage setting process $\xi_t^W$ permanently influences employment $e_t$, and unemployment $u_t$, but has no long-term impact on average wages $w_t$, and labor productivity $lp_t$;
- labor supply disturbance $\xi_t^N$ has no long-term impact on all of the analyzed variables,
- labor demand shock $\xi_t^V$ shall change the long-run levels of employment $e_t$, and unemployment $u_t$, as well as of wages $w_t$, but shall be neutral for labor productivity $lp_t$;

These conclusions establish the catalogue of long-term restrictions that could potentially be applied in the empirical model.

# 2 Empirical panel SVECM

This section describes the empirical model used in the analysis. We start with description of the panel VECM and employed estimation procedure. Then dynamic properties of time series are analyzed and estimation results are discussed. The section ends with presentation of identifying restrictions on SVECM used in following sections.

## 2.1 Estimation

The analysis is based on a panel VECM with the following reduced-form formulation:

$$\Delta y_t^n = \alpha^n \beta^T y_{t-1}^n + \sum_{p=1}^{P} \Gamma_p \Delta y_{t-p}^n + d^n + \xi_t^n \qquad (1)$$

for $t = 1, 2, ..., T$, where $y_t^n$ stands for the n-th country's $m \times 1$ vector of modeled variables, n = 1,2,...,N, $\alpha^n$ is a $m \times r$ matrix of loading factors for $r$ being a dimension of the cointegration space which basis vectors are stored in an $m \times r$ matrix $\beta$, $\Gamma_p$'s, p=1,2,...,P, are $m \times m$ matrices and $d^n$ is a $m \times 1$ vector of individual effects. It is assumed that $\beta$'s and $\Gamma_p$'s are common for all panel units.

Exogenous variables are not included in (1), however the panel setting requires controlling for common effects (Breitung and Pesaran, 2005). We treat these effects as quasi-exogenous, ie. the vector of modeled variables is partitioned into $y_t^n = (y_t^{n,1}, y_t^{n,2})^T$ where $y_t^{n,1}$ stands for $m_1 \times 1$ vector of strictly endogenous variables and $y_t^{n,2}$ for $(m-m_1)\times 1$ vector of quasi-exogenous ones. It is assumed that quasi-exogenous variables do not enter cointegration relations and are not influenced by strictly endogenous ones. For example if $m=6$, $m_1=4$, $r=1$ and $P=1$ (as in our case), then $y_t^{n,1}$ and $y_t^{n,2}$ would be 4×1 and 2×1 vectors respectively, and the following exclusion restrictions would be enforced

$$\begin{aligned}\Delta\begin{pmatrix} y_t^{n,1} \\ y_t^{n,2}\end{pmatrix} &= \begin{pmatrix} * \\ * \\ * \\ * \\ 0 \\ 0 \end{pmatrix}\begin{pmatrix} * & * & * & * & 0 & 0\end{pmatrix}\begin{pmatrix} y_{t-1}^{n,1} \\ y_{t-1}^{n,2}\end{pmatrix} + \\ &+ \begin{pmatrix} * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ 0 & 0 & 0 & 0 & * & * \\ 0 & 0 & 0 & 0 & * & * \end{pmatrix}\Delta\begin{pmatrix} y_t^{n,1} \\ y_t^{n,2}\end{pmatrix} + \begin{pmatrix} * \\ * \\ * \\ * \\ * \\ * \end{pmatrix} + \xi_t^n\end{aligned} \tag{2}$$

Such an approach has several advantages. Dynamic properties of endogenous and quasi-exogenous variables are accounted for within the same model. Analyzes based on the MA representation of $y_t^n$ explicitly take into account quasi-exogenous variables, but can be conducted as usually. Responses of endogenous variables to structural quasi-exogenous shocks, variance decompositions and retrospective simulations of $y_t^n$ with respect to these shocks can be investigated. Moreover, interpretation of results is coherent with interpretation of experiments based on endogenous variables.

Reduced form model 1 is estimated with a two-step GLS-based procedure. Such an approach turns out to be advantageous in comparison with maximum likelihood and nonparametric methods, especially for short time series, see Brüggemann and Lütkepohl (2004) or Breitung (2005). Since in the second step of the procedure Breitung (2005) is followed, we utilize a panel extension of Ahn and Reinsel (1990) and Saikkonen (1992) results. Unlike in Breitung (2005), however, here also the first step involves panel as well as GLS estimation.

Let $y^n=[y_T^n, y_{T-1}^n, ..., y_1^n]$ stand for a $m\times T$ matrix of observations of the n-th, n=1,2,...,N, panel unit and $x^n$ for a $k\times T$, $k\geq 1$, matrix of regressors for $y^n$ (ie. a matrix of regressors for the relation of the form of $y^n = ... + A^n x^n$, for $A^n$ being a $m\times k$ matrix of coefficients). We will need only two cases: $k=1$, when $A^n$ represents a constant in the model, and $k=Pm$ when $A^n$ is a matrix of autoregressive coefficients.

Let $y\!=\![y^1, y^2, ..., y^N]$ stand for a $m\!\times\! TN$ matrix of observations for the whole panel and $x = [x^1, x^2, ..., x^N]$ for a $k \times TN$ matrix of regressors for consecutive panel units.

A generic building-block of VECM for $y$ enters the model as follows[3]

$$y = [y^1, y^2, \ldots, y^N] = \ldots + [A^1 x^1, A^2 x^2, \ldots, A^N x^N] \tag{3}$$

for $A^n$, $n\!=\!1, 2, \ldots, N$, being $m\!\times\! k$ matrices of coefficients. If $A^n$'s in (3) are common across panel units, then $A^n\!=\!A$ for all $n$, and $A$ enters the model in the form of $y = ... + Ax$. If $A^n$'s are unit specific, than they can be stacked together into the $m \times kN$ matrix $\tilde{A}\!=\![A^1, A^2, \ldots, A^N]$, and for a $kN\!\times\! TN$ matrix $\tilde{x}\!=\!mdiag(x^1, x^2, \ldots, x^N)$, where *mdiag* is a matrix generalization of the diagonal matrix builder operator, ie.:

$$mdiag(x^1, x^2, \ldots, x^N) = [e_1 \otimes x^1, e_2 \otimes x^2, \ldots, e_N \otimes x^N]$$

matrix $\tilde{A}$ enters the model in the form of $y = \ldots + \tilde{A}\tilde{x}$. Hence, a general model for $y$ can be expressed as

$$y = Ax + \tilde{A}\tilde{x} + \Xi \tag{4}$$

where $A$ consists of common coefficients (which are associated with regressors in $x$), and $\tilde{A}$ consists of unit-specific coefficients (which are associated with regressors in $\tilde{x}$).

Using this notation, (1) can be rewritten as:

$$y = \tilde{A}_1\tilde{x_1} + Ax + \tilde{A}_2\tilde{x_2} + \Xi \tag{5}$$

where $\tilde{A}_1 = [\alpha^1\beta^T, \alpha^2\beta^T, ..., \alpha^N\beta^T] = [\Pi^1, \Pi^2, ..., \Pi^N]$, $A = [\Gamma_1, \Gamma_2, \ldots, \Gamma_P]$, $\tilde{A}_2\!=\![d^1, d^2, \ldots, d^N]$ and $x$, $\tilde{x_1}$ and $\tilde{x_2}$ are properly chosen regressor's matrices. GLS estimates of (5) can be calculated. Standard normalizing restriction, $\beta^T\!=\![I_{r\times r}|\beta_0^T]$, leads to

$$\Pi^n = [\alpha^n|\alpha^n\beta_0^T] \tag{6}$$

for $n = 1, 2, \ldots, N$, so that estimates of $\alpha^n$'s are encoded in the first $r$ columns of respective $\Pi^n$'s. From the partitioning (6) it follows that

$$\tilde{A}_1\tilde{x}_1 = \sum_{i=1}^{N} \alpha_i p_{i,1} + \sum_{i=1}^{N} \alpha_i\beta_0^T p_{i,2} \tag{7}$$

where $p_{i,j}$ $(i\!=\!1, 2, \ldots, N,\ j\!=\!1, 2)$ are appropriate partitions of $\tilde{x}_1$.

[3] "..." indicates that the generic building-block can be accompanied by other blocks in the analogous form.

Estimated model (5) can then be rearranged as

$$y - \hat{A}x - \hat{\hat{A}}_2\tilde{x}_2 - \sum_{i=1}^{N} \hat{\alpha}_i a_{i,1} = \sum_{i=1}^{N} \alpha_i \beta_0^T a_{i,2} + \Psi \tag{8}$$

GLS estimates of $\beta_0$ can be obtained from (8), for instance by noting that

$$\begin{aligned} vec(y - \hat{A}x - \hat{\hat{A}}_2\tilde{x}_2 - \sum_{i=1}^{N} \hat{\alpha}_i p_{i,1}) &= \sum_{i=1}^{N} vec(\alpha_i \beta_0^T p_{i,2}) + vec(\Psi) = \\ &= (\sum_{i=1}^{N} (p_{i,2} \otimes \alpha_i)) vec(\beta_0^T) + vec(\Psi) \end{aligned} \tag{9}$$

Structural shocks are identified for each panel unit separately, although identifying restrictions are common. Correlated shocks $\xi^n$ are linked to their fundamental drivers $u_t^n$ by the $m \times m$ contemporaneous impact matrix $B^n$: $\xi^n = B^n u_t^n$. If $\xi_t^n$ are white with covariance $\Sigma^n$ and $u_t^n$ with covariance $I$, than $\Sigma^n = B^n (B^n)^T$. This imposes $\frac{m(m+1)}{2}$ out of $m^2$ identifying restrictions on $B^n$. Remaining linearly independent restrictions are zero-type restrictions imposed on elements of $B^n$ and $E^n B^n$, where:

$$E^n = \beta_\perp [(\alpha_\perp^n)^T (I - \sum_{p=1}^{P-1} \Gamma_p) \beta_\perp]^{-1} (\alpha_\perp^n)^T$$

is a long-run impact matrix in the Beveridge-Nelson representation of $y_t^n$:

$$y_t^n = \sum_{i=1}^{t} E^n \epsilon_i^n + \sum_{i=0}^{\infty} E_i^n \epsilon_{t-i} + \tilde{y}_0^n \tag{10}$$

where $\tilde{y}_0^n$ represents initial values of $y_t^n$ and matrices $E_i^n$ are estimated with the procedure proposed by Hansen (2000).

Zero-type restrictions imposed on $B^n$ and $E^n B^n$ are in the form of $Svec(B) = 0$, and $Lvec(E^n B^n) = 0 \equiv L(I \otimes E) vec(B) = 0$, which are equivalent to $vec(B^n) = S_\perp \gamma$, and $vec(B^n) = (I \otimes E)_\perp \gamma$ respectively, for $\gamma$ representing unconstrained elements of $B^n$. The two latter conditions can be combined together to $vec(B^n) = R\gamma$, which constitutes a constraint for a maximization of the likelihood function for a VAR(P+1) model corresponding to the VECM(P) model 1. This likelihood can be expressed in terms of $B^n$. $B^n$ is determined as a minimizer of this function by means of the Amisano and Giannini (1997) scoring algorithm.

## 2.2 Data

The empirical model consists of six variables

$$Y = [y - p - n, e - n, u - n, w, eu_{HP}, cis_{HP}] \tag{11}$$

divided into two categories: endogenous (domestic) and quasi-exogenous (foreign) ones. Endogenous variables are: GDP per worker ($y$–$p$ –$n$), employment rate ($e$–$n$), unemployment indicator ($u$–$n$) and average real wages ($w$–$p$). In line with Breitung and Pesaran (2005) suggestion, common effects, which entail cross-sectional dependence, are accounted for. Observable common effects, modeled as quasi-exogenous variables, are used. Since a panel of small open economies is investigated, we employ trade-related variables. They control for global economy developments, which affect all countries in a rather similar way. However, because of increasing integration of CEE countries with the global trade system,[4] and because of possibly diverse exposure of particular countries to foreign shocks,[5] country-specific measures of foreign demand fluctuations are used. They are defined as business cycle component of a given country exports to EU15 and CIS economies.[6] Balanced panel of quarterly data spanning from 1996 to 2007 is used. Variables' definitions and description of data used is provided in Table 1.

Table 1: Variables and data used

| | |
|---|---|
| $y-p-e$ | real GDP per worker, measured in Purchasing Power Standards (calculated by Eurostat) and divided by number of employed; |
| $e-n$ | employment rate (share of employed in population aged 15-64); |
| $u-n$ | unemployment indicator (share of unemployed in population aged 15-64); |
| $w-p$ | average real gross wages, measured in national currency (because of availability of the data) and deflated by HCPI; |
| $eu_{HP}$ | business cycle (HP filtered) component of exports to EU15 countries, measured as logarithm of exports in constant prices; |
| $cis_{HP}$ | business cycle (HP filtered) component of exports to CIS countries, measured as logarithm of exports in constant prices. |

Remarks: If not explicitly stated, data comes from Eurostat. Average wages in Lithuania for 1996-1997 and in Slovakia (1996-1999) were calculated on the basis of national statistical offices data. Wages in Poland before 1999 were grossed up. All wages data were initially yearly and have been disaggregated to the quarterly series with Booot-Feibes-Lisman filter. Quarterly labor cost index (Eurostat) was used as a leading variable in filtering.

[4]Between 1996 and 2006 share of exports in GDP of all examined countries substantially increased, and in case of Czech Republic, Slovakia and Hungary - even doubled.

[5]Deep economic slowdown of Baltic countries after the Russian crisis in 1998 and almost no consequences of that shock for Slovenia and Hungary, offers probably the most striking anecdotal evidence of such possibility.

[6]Major trade partners of NMS economies in the examined period.

## 2.3 Variables' dynamic properties

Now we turn to dynamic properties of the NMS8 time series. Since for each variable only 48 observations per country are available, a panel unit root test introduced by Pesaran (2003) was applied. Breitung and Pesaran (2005) indicate that traditional unit root tests have unacceptably low power in small samples. Moon and Perron (2005) argue in turn, that Pesaran (2003) test, as a so-called second generation test, behaves satisfactorily in small samples.

Table 2: Critical probability values of Pesaran (2003) panel unit root test

| | $I(1)$ vs. $I(0)$ | $I(2)$ vs. $I(1)$ |
|---|---|---|
| GDP per worker | 0.165-0.539 | 0.000 |
| Real wages | 0.490-0.994 | 0.000 |
| Employment rate | 0.082-0.180 | 0.000 |
| Unemployment ind. | 0.000-0.283 | 0.000 |
| EU demand | 0.000 | 0.000 |
| CIS demand | 0.000 | 0.000 |

Remarks: The table reports critical probability values for which the null hypothesis can be rejected. Reported intervals represent ranges for tests with 1 to 3 lags.

Results reported in Table 2 suggest that GDP *per worker* and average real wages should be modeled as I(1) variables. As far as unemployment and employment are concerned, results were not that clear-cut. Generally, the tests indicated that these variables should also be modeled as I(1). However, this result is not in line with empirical studies conducted for other countries.[7] We believe that results for employment and unemployment are small sample phenomena, reflecting the fact that the time series did dot reveal sufficient mean reversion in the available (short) sample. We proceed assuming that data generating processes of all four domestic variables include stochastic trend components. Quasi-exogenous variables in turn seem to be stationary.

Results of Saikonnen and Lütkepohl (2000) cointegration rank test for each country are reported in Table 3. In five out of eight countries one cointegration relation was identified. In case of Latvia and Slovenia the null of $r=0$ could not be rejected, suggesting a VAR for first differences as an alternative. For Lithuania in turn, a two or even three dimensional cointegration space could be considered. However, as one relation is prevailing, in what follows we condition the analysis on one homogenous cointegration relation being identified in the data.[8]

[7] Nelson and Plosser (2002) argued for stationarity of US unemployment, Papell at al. (2000) and Johansen (2002) - of unemployment in several European countries, Camarero et al. (2004) and Hurlin (2004) using panel tests rejected hypothesis that unemployment is I(1) for a range of OECD countries, and León-Ledesma and MacAdams (2003) did so for CEE countries.

[8] In line with Jacobson, Vredin and Warne (1997) result for Scandinavian countries and

Table 3: Critical probability values of Saikonnen-Lütkepohl (2000) cointegration rank test

| $H_0$ | Czech Rep. | Estonia | Latvia | Lithuania | Hungary | Poland | Slovenia | Slovakia |
|---|---|---|---|---|---|---|---|---|
| $r=0$ | 0.06 | 0.00 | 0.58 | 0.00 | 0.00 | 0.01 | 0.18 | 0.01 |
| $r=1$ | 0.15 | 0.28 | - | 0.00 | 0.28 | 0.12 | - | 0.36 |
| $r=2$ | - | - | - | 0.05 | - | - | - | - |
| $r=3$ | - | - | - | 0.12 | - | - | - | - |
| $r$ | 1 | 1 | 0 | 2 | 1 | 1 | 0 | 1 |

Null is $r=r_0$ and the alternative is $r>r_0$. Results for a test with a constant term and one lagged difference, see Lütkepohl and Saikkonen (2000).

## 2.4 Estimation results

Cointegration relation[9] can be interpreted as a wage setting relation[10]

$$\begin{array}{llll} (w-p) = & 0.701(y-p-e) & +0.797(e-n) & +0.099(u-n) \\ & (54.19) & (7.56) & (6.79) \end{array} \tag{12}$$

One would expect that in the long run wages follow productivity and are not influenced by neither employment nor unemployment. This implies that GDP per worker coefficient in the wage setting equation equals unity, whereas two remaining ones are insignificant. Reported results indicate, however, that in the studied sample such a stylized relationship is violated. Relation (12) suggest that in the 1996-2007 period, evolution of GDP *per* worker in NMS8 countries propagated into real wages less than proportionally.[11] This result may reflect the fact that GDP *per* worker is not equivalent to labor productivity *sensu stricto*, and that in NMS countries GDP *per* worker growth might have surpassed labor productivity dynamics because of substantial investment (also in technologically more advanced equipment) in the analyzed period.[12]

Unemployment and employment also significantly enter the wage setting scheme, which we believe is a small sample phenomenon. Positive unemployment coefficient mirrors the mechanism which links unemployment and average wages - as the unemployment rises, low-productivity and low-wage workers loose their jobs relatively more often than high-productivity individuals and the evolution of average wage in the aftermath of unemployment

Brüggemann (2006) for Germany.

[9]Foreign-demand variables are excluded.

[10]See Breitung, Brüggemann and Lütkepohl (2004) and Brüggemann (2006).

[11]Indeed, as Magda and Szydlowski (2007) show, between 1995 and 2007 GDP *per* worker grew faster than real wages in all NMS countries but Lithuania and Czech Republic.

[12]According to Eurostat data, the average investment to GDP ratio in 1996-2007 ranged from 21 percent in Poland to 29 percent in Estonia.

increase can be ambigous. Indeed, Myck, Morawski and Mycielski (2007) show that about $\frac{1}{4}$ of average wage growth in 1996-2003 in Poland can be attributed purely to changes in employment structure. In other NMS countries, characterized by similar institutional and structural features of economy, paralel developments might have occurred.

Cointegration relation (12) is stationary. Table 4 reports country-specific loading factors estimates. They support interpretation of the cointegrating vector (12) in terms of the wage setting relation: if wages exceed (are below) cointegration-consistent equilibrium level, a pressure mitigating (strengthening) their growth rate is triggered. Furthermore, significant estimates in the third row of Table 4 imply that wage shocks influence unemployment dynamics: wages above cointegration-consistent equilibrium tend to boost unemployment. On the other hand, high unemployment does not seem to dampen wages in the sample suggesting high wages inertia (i.e. rigidity) in the available sample for NMS8 countries.

Table 4: Loading factors.

| | Czech Rep. | Estonia | Latvia | Lithuania | Hungary | Poland | Slovenia | Slovakia |
|---|---|---|---|---|---|---|---|---|
| $w-p$ | -0.15 | -0.15 | -0.20 | -0.21 | -0.13 | -0.31 | -0.37 | -0.37 |
| $y-p-n$ | 0.09 | 0.57 | -0.19 | 0.05 | 0.08 | 0.09 | 0.17 | 0.05 |
| $e-n$ | -0.13 | -0.9 | 0.1 | -0.13 | 0.01 | -0.26 | -0.04 | -0.06 |
| $u-n$ | **2.07** | 0.34 | **-0.27** | **1.22** | **-0.84** | **1.25** | 1.47 | 0.22 |
| $eu_{hp}$ | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| $cis_{HP}$ | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

Bolded font indicates significance of a given parameter at a 0.05 nominal significance level. Bolded zero indicated significant exclusion restriction. Estimates obtained using panel VECM estimator presented in subsection 2.1.

### 2.5 Structural restrictions

Interpretation of structural shocks is underlaid by the stylized DSGE model presented in the previous section, and is typical for the literature, e.g. Dolado and Jimeno (1997), Jacobson, Verdin and Warne (2997), Balmaseda, Dolado and Lopez-Solido (2000), Breitung, Brüggemann and Lütkepohl (2004), Brüggemann (2006). Disturbances in GDP *per* worker, real average wages, employment, and unemployment are interpreted as productivity, wage setting, labor demand and labor supply shocks respectively.

Existence of exactly one cointegration relation entails that at least three out of four structural innovations can exert permanent effects. From the catalogue of long-run restrictions derived in subsection 1.3 from DSGE model, we pick the restriction of no permanent effects of productivity innovations on unemployment and employment.[13] Additionally, we assume that wage

[13] Basically we implement the so-called Nickell rule which states that productivity shocks do not influence employment and unemployment levels in the long run, and are completely

shocks have only transitory effects on average wages. This assumption follows from the fact that real wages are result of an "empirical equilibrium" (12). Moreover, a DSGE model implies that wages shocks (i.e. shifts in relative bargaining strength of workers) in the long-run influence unemployment and employment, but are neutral for average wages (see Fig. 1).

Foreign demand shocks, since they do not enter cointegration relation, are assumed not to influence wages in the long run. These shocks are also expected not to impact permanently each other. Domestic variables are restricted not to influence trade-related ones in the long run, in line with quasi-exogenous treatment of the latter.[14]

Identification of SVECM is completed by imposing contemporaneous exclusion restrictions. It is assumed that: (i) productivity innovations influence wages with a lag of at least one quarter, (ii) wage shocks affect do not influence employment immediately, (iii) labor supply innovations influence employment with a lag of at least one quarter, (iv) foreign demand shocks do not influence unemployment immediately.[15]

Hence, long-run ($EB$) and short-run ($B$) restriction matrices for

$$Y = [(w-p), u-n, e-n, y-p-e, eu_{hp}, cis_{HP}]$$

are as follows

$$EB = \begin{pmatrix} 0 & * & * & * & 0 & 0 \\ * & * & * & 0 & * & * \\ * & * & * & 0 & * & * \\ * & * & * & * & * & * \\ 0 & 0 & 0 & 0 & * & 0 \\ 0 & 0 & 0 & 0 & 0 & * \end{pmatrix} \quad (13) \qquad B = \begin{pmatrix} * & 0 & * & 0 & * & * \\ * & * & * & * & 0 & 0 \\ 0 & 0 & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \end{pmatrix} \quad (14)$$

# 3 Impulse responses and variance decompositions

We begin analysis of SVECM with discussion of propagation of structural shocks on NMS labor markets. Figures $2-6$ show country-specific responses of employment, unemployment, average wages and GDP per worker. They are normalized in such a way that the initial response of a given variable to its structural disturbance (eg. employment in case of labor demand shock) equals one percent.[16]

absorbed by output per worker and real wages. Such rule was empirically confirmed for a range of developed economies by eg. Bean and Pissarides (1993), Aghion and Howitt (1994) or Mortensen (2005).

[14] Hence in SVECM setting foreign-demand variables are not influenced by domestic ones at any horizon.

[15] Which means that foreign demand shocks enter domestic labor market *via* GDP and employment, which entail changes in unemployment.

[16] Appendix A presents country by country impulse responses, with *bootstrapped* confidence intervals, of employment and unemployment to domestic structural shocks.

## 3.1 Labor demand and supply shocks

Labor demand shocks uniformly increase employment, and depress unemployment, although some differences between NMS countries are visible when it comes to the scope of response and its persistence (see Figure 2). Except for Czech Republic and Lithuania, labor demand shocks decrease unemployment in both short- and long-run. Such long-lasting impact of labor demand shocks was also found by Breitung, Brüggemann and Lütkepohl (2004) for Canada and Brüggemann (2006) for Germany. On the other hand, transitory reaction of unemployment in Czech Republic and Lithuania resembles the results by Jacobson, Vredin and Warne (1997) for Norway and Sweden.[17] The response of average wages to a positive demand shock is in general moderate and pro-cyclical, with exception of Slovenia and Latvia where it is slightly counter-cyclical. It might be the case that in these two countries positive labor demand innovations to greater extent than in others increase[18] employment of low-productivity, low-wage workers, which leads to higher employment and lower average wages.

Labor supply shocks (see Figure 3) rise unemployment. Poland stands out as the only NMS economy where these increases were found to be merely transitory, lasting 6-8 quarters. As some negative supply shocks in Poland could be perceived as triggered by institutional factors, especially the welfare system (see Fortuny, Nesporova and Popova, 2003; Bukowski and Lewandowski, 2006; Bukowski, Koloch and Lewandowski, 2007), results suggest that depressing labor supply in Poland could have led merely to short-lived reduction in unemployment. On the other hand, Slovakia stands out as the only country where unemployment responses to labor supply shocks stabilize after few quarters at higher than initial level, amounting to 2 percent. Concurrently, in Slovakia wages are depressed, if only slightly. In all other NMS economies average wages do not react significantly, which may indicate wage rigidities.

## 3.2 Innovation in wages and productivity shocks

As Figure 4 shows, positive wage shocks generally reduce employment and increase unemployment, in Lithuania and Poland even in the long run. Propagation of (positive) wage shocks in Slovakia seems quite puzzling, as unemployment declines and employment rises, however after few quarters these responses are reversed. Such mechanism might be due to the fact that ,,substantial" wage shocks in Slovakia were related to political business cycle. The government froze most of administered prices and boosted wages in public sector before the election in 2002 (see OECD, 2003; Bukowski, Koloch and

[17]We do not think, however, that this difference mirrors any specific structural and institutional features of these two CEE labor markets.

[18]Or rather, increased in the analyzed period.

Lewandowski, 2007). In small sample that we dispose over, such episode might dominate the pattern of wage shocks propagation and led to atypical responses presented on Figure 4.

The model also shows that positive productivity shock temporarily depresses employment and rises unemployment, but in the long-run is completely absorbed by higher output per worker and wages (Figure 5).[19] This temporary employment decline suggests that in short run the so-called destruction effect of productivity surge dominates over so-called capitalization effect, but in long run it becomes inferior (Altig et al., 2005; Fisher, 2006; Michelacci and Lopez-Salido, 2007). Such pattern is analogous to the one revealed in various SVAR/SVECM studies of US and UE15 economies (Blanchard and Quah, 1989; Balmaseda, Dolado and Lopez-Salido, 2000; Brüggemann, 2006). The spike in unemployment seems to be absorbed after roughly 3-4 quarters in Estonia, Poland and Slovenia, and after nearly double period in Czech Rep. and Hungary. These two countries also emerge as the ones where elasticity of unemployment to productivity shocks is, according to the estimates, the highest among NMS.

### 3.3 Foreign demand shocks

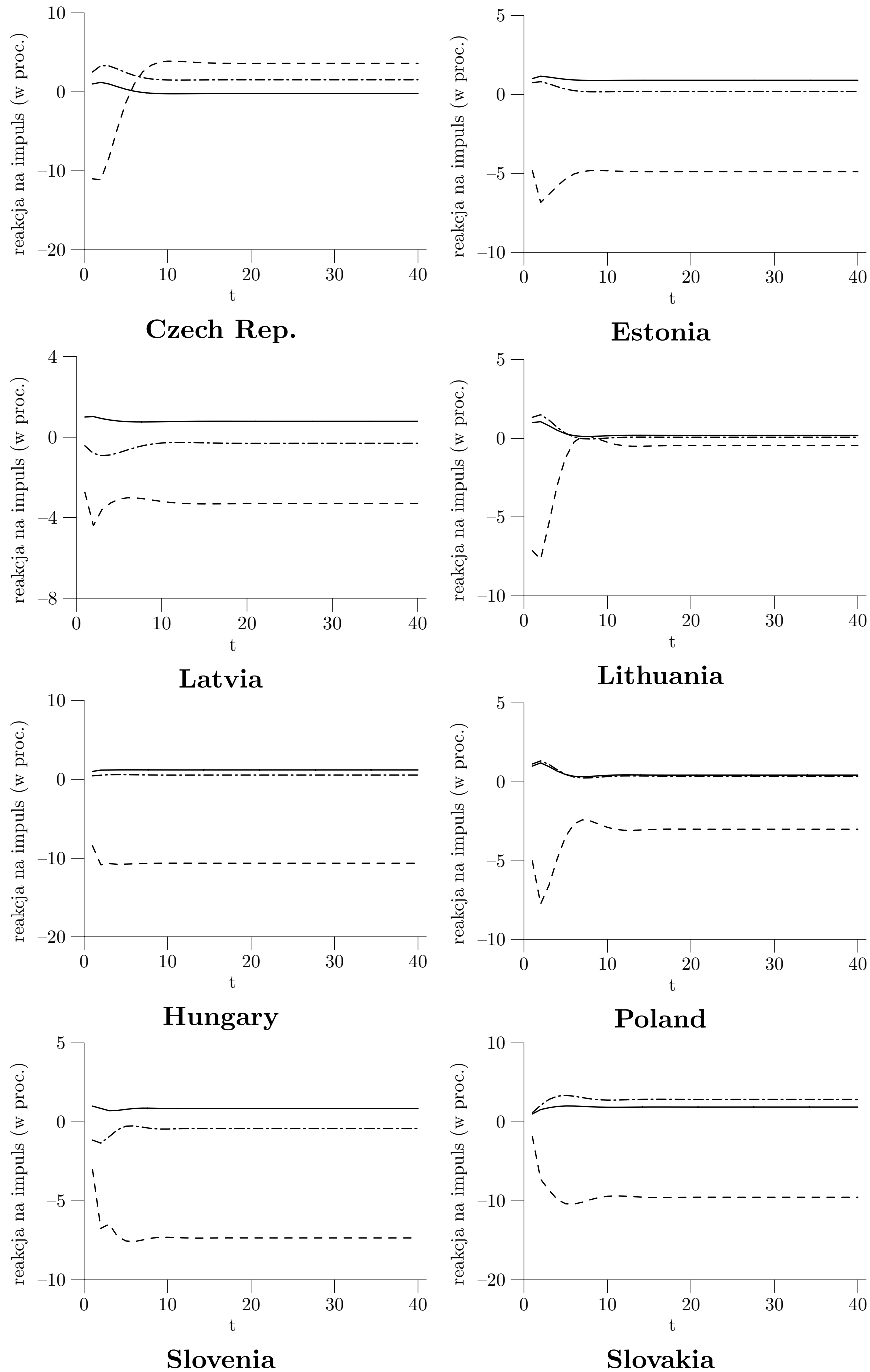
*Quasi-exogenous* specification of foreign demand variables allows us to study their impact on domestic variables in a usual way. Structural disturbances to exports should be interpreted differently than domestic structural shocks. Foreign demand variables were constructed as business cycle fluctuations of exports (see Table 1), so structural impulses lead to "small" departures from such frequency movements of the variable, instead of departures from evolution of variables' levels, as in case of domestic variables.

Figures 6-7 show that responses of NMS labor markets to disturbances in foreign demand fluctuations are in line with intuition - positive deviation of exports from systematic cyclical evolution increases GDP per worker, average real wages, employment, and decreases unemployment. These reactions are however rather limited in scope. Disturbances in exports to CIS countries seem more prominent in case of Baltic states, Poland and Slovakia It is in line with broad consensus that these countries were much severely affected by the Russian crisis than other three economies in our panel.[20] In case of EU15 exports, responses in Czech Republic, Hungary and Slovakia are stronger than in the remaining countries, which is coherent with their substantial integration with "old" EU.

[19] Proportion between long-term response of GDP per worker and average real wages is obviously determined by estimated cointegration relation (12).

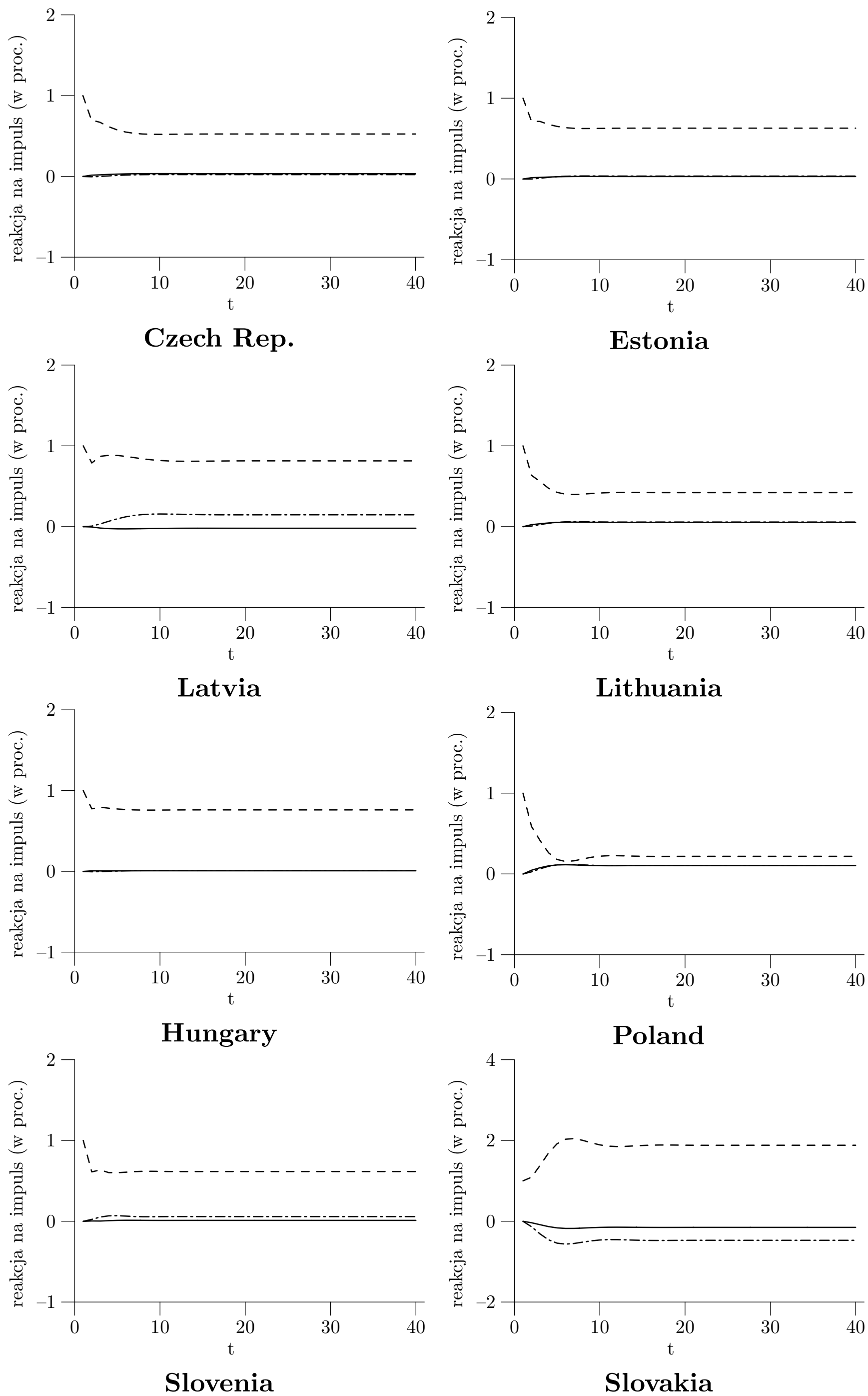
[20] Bukowski and Lewandowski (2006) discuss this point and factors behind it in more detail.

**Figure 2: Impulse responses to labor demand shock**



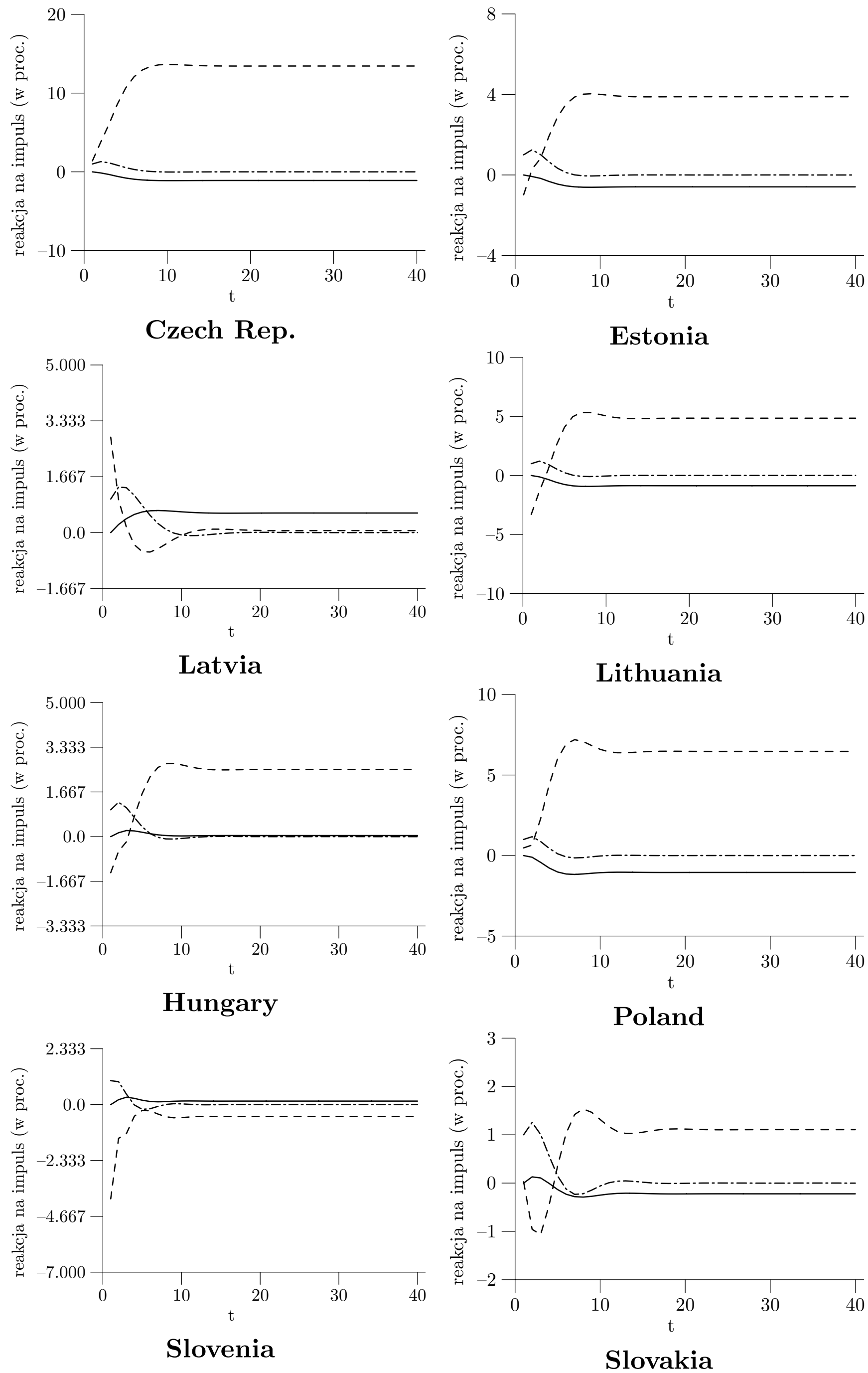

solid line – employment; dashed line – unemployment; one-dot line – average wages.

**Figure 3: Impulse responses to labor supply shock**



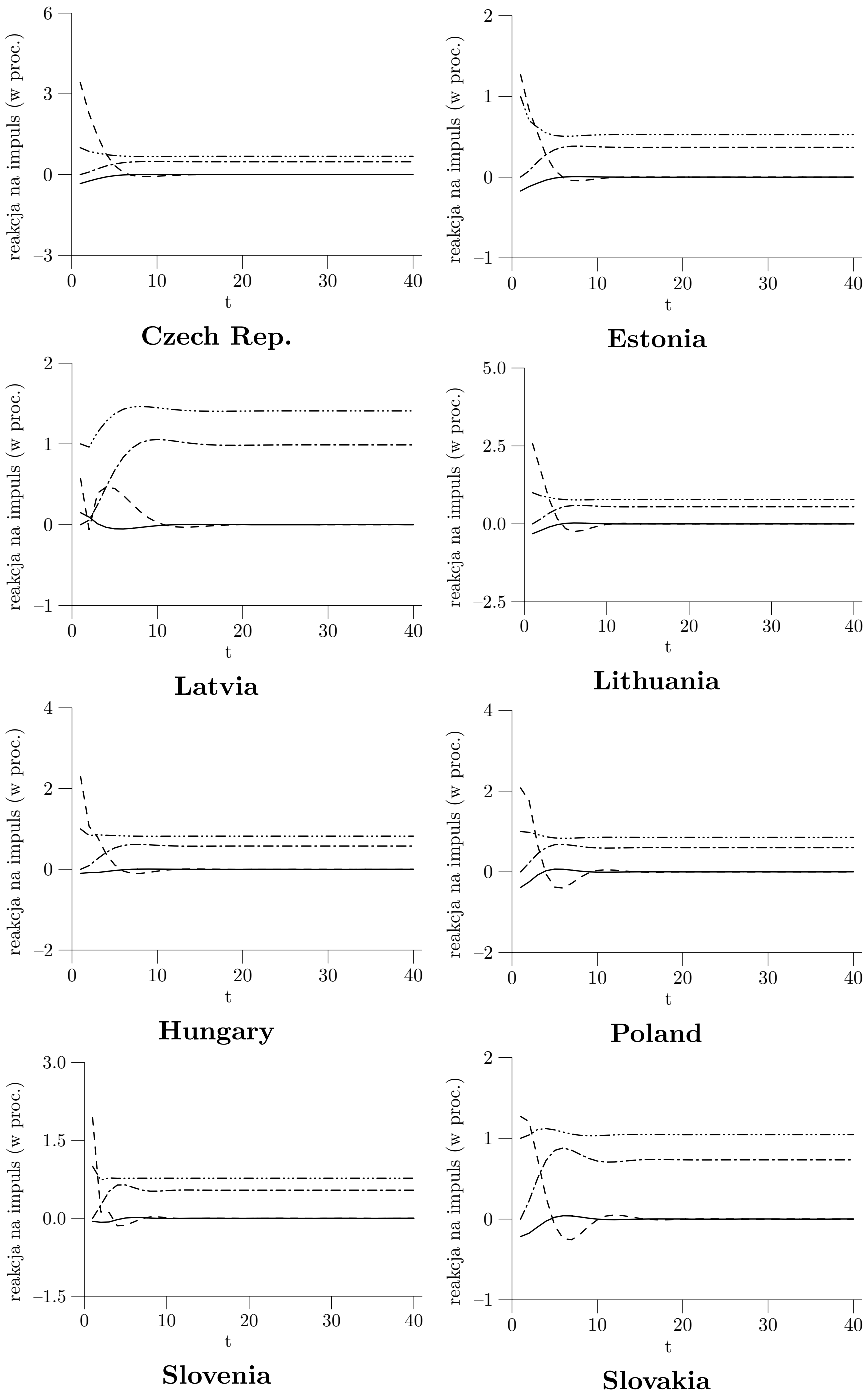

solid line – employment; dashed line – unemployment; one-dot line – average wages.

**Figure 4: Impulse responses to innovation in wages**



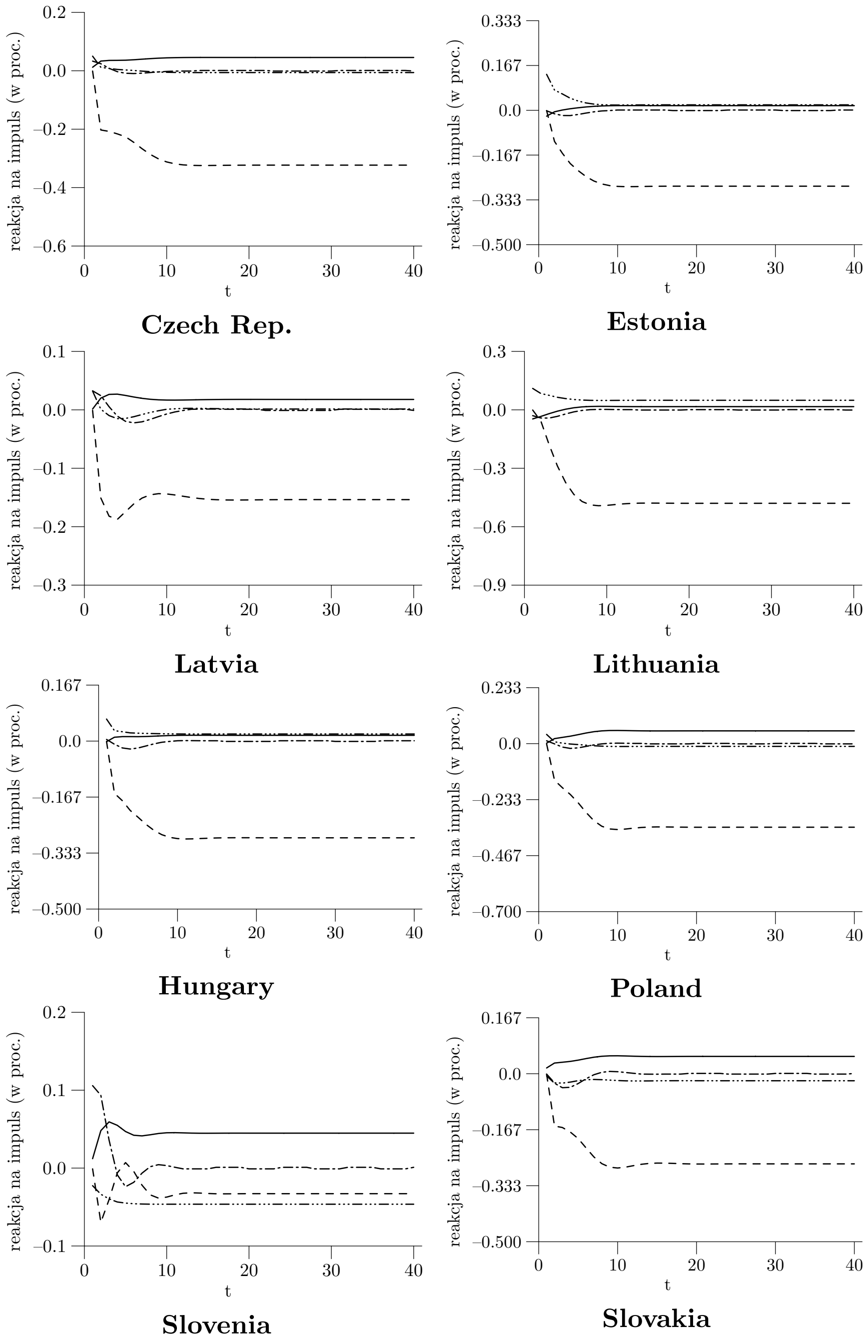

solid line – employment; dashed line – unemployment; one-dot line – average wages.

**Figure 5: Impulse responses to productivity shock**



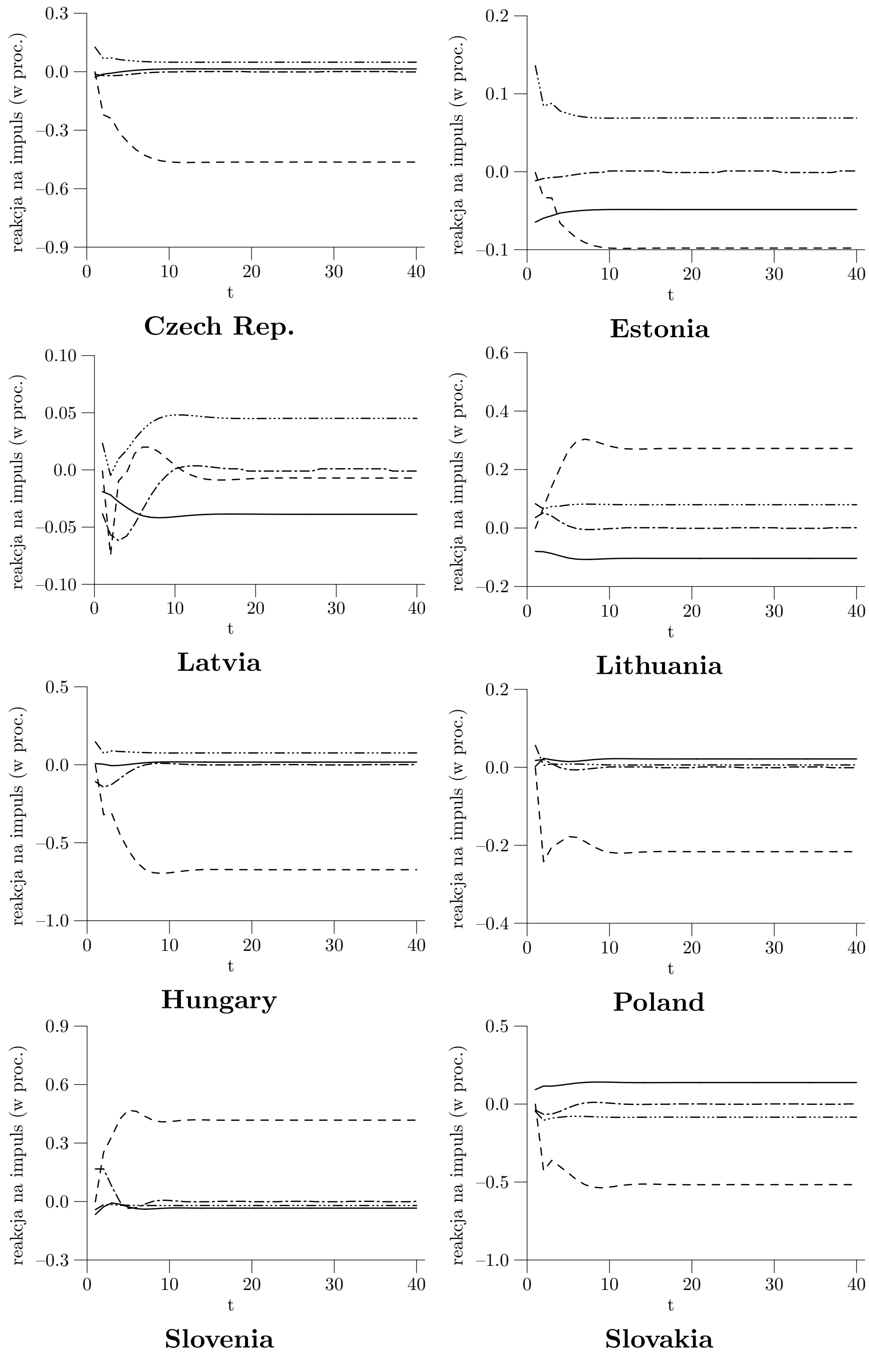

solid line – employment; dashed line – unemployment; one-dot line – average wages, three-dots line – GDP per worker.

## Figure 6: Impulse responses to CIS demand disturbance




solid line – employment; dashed line – unemployment; one-dot line – average wages, three-dots line – GDP per worker.

**Figure 7: Impulse responses to UE15 demand disturbance**

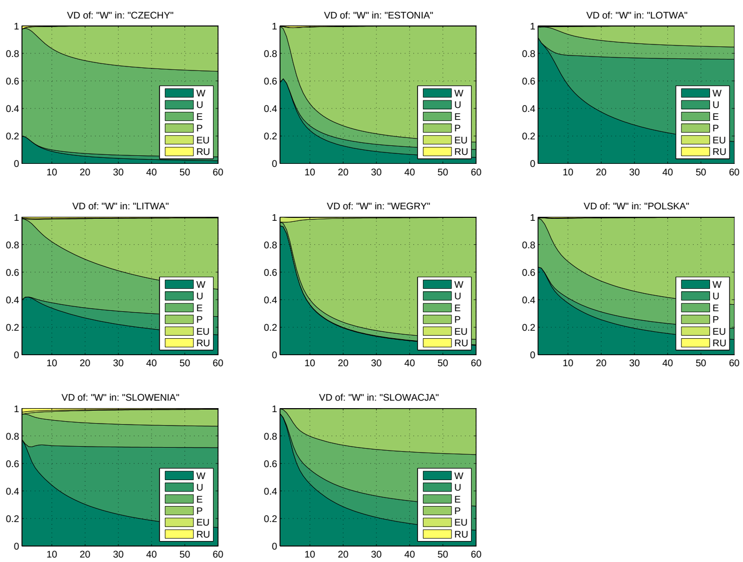



solid line – employment; dashed line – unemployment; one-dot line – average wages, three-dots line – GDP per worker.

### 3.4 Historical variance decompositions

Next, we discuss the role played by each shock in explaining the variability of average wages, employment and unemployment. Figure 8 suggests that Czech Republic, Latvia, Slovakia and Slovenia are the economies where transmission of productivity shocks to average wage levels take the longest time. In these countries labor demand and supply shocks account for especially large part of wages' variability in short- and medium-term. Latvia stands out also as a country with the highest contribution of wage shocks to the variance of wages in all horizons.

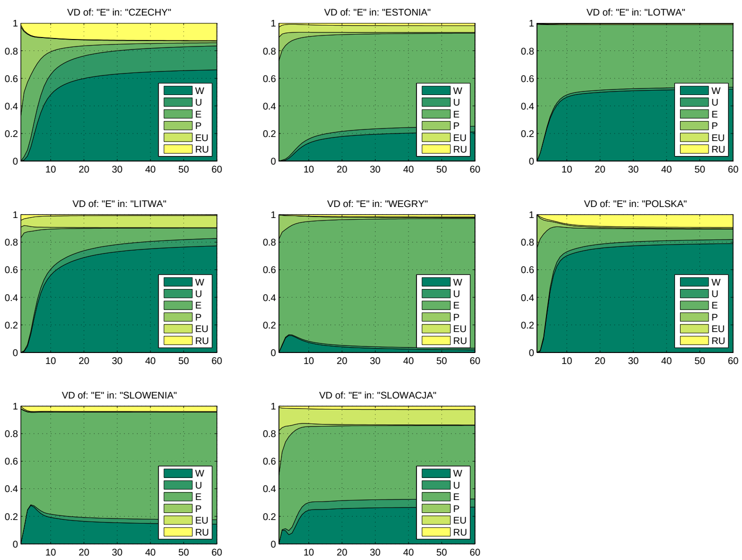
**Figure 8: Historical variance decomposition of real average wages**



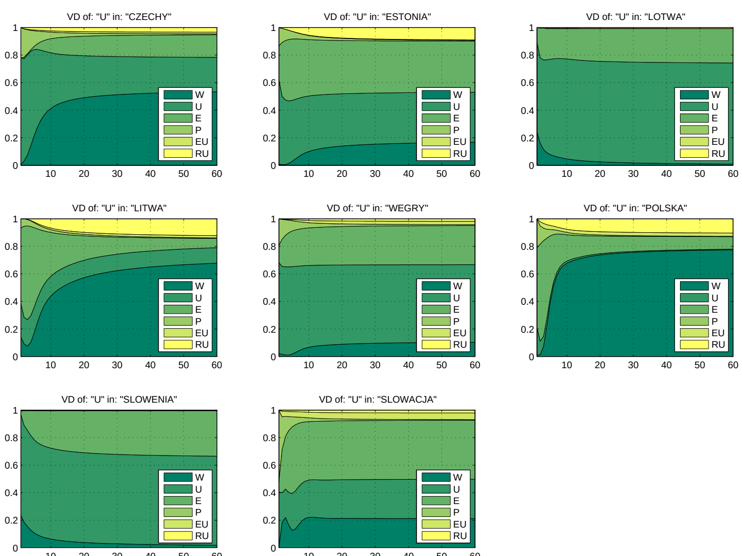

$w$– real wages; $u$ – labor supply; $e$ – labor demand; $p$ – productivity; $ue$ – fluctuations of EU15 demand; $rus$ – fluctuations of CIS demand.

Productivity shocks drove variability of wages dominantly (explaining more than 60 percent) even in 10-quarter horizon in Estonia and Hungary. In Poland these shocks explain more than half of variance of average wages after roughly 6 years. Juxtaposing the results with Balmaseda, Dolado and Lopez-Salido (2000), one can see that only Estonia and Hungary exhibit transmission of productivity shocks into wages comparable to the one observed in most OECD countries. Interestingly, Ireland was the only country where labor demand and supply shocks explained variability of wages to the degree comparable to that in Czech Republic, Lithuania, and Slovenia.

## Figure 9: Historical variance decomposition of employment rate




## Figure 10: Historical variance decomposition of unemployment indicator




$w$– real wages; $u$ – labor supply; $e$ – labor demand; $p$ – productivity; $ue$ – fluctuations of EU15 demand; $rus$ – fluctuations of CIS demand.

As regards employment, labor demand shocks dominate in a very short run (up to 4 quarters) in all countries.[21] However, as the horizon expands, influence of labor demand shocks remains strong in Estonia, Hungary, Slovakia and Slovenia, whereas the contribution of wage shocks becomes prevailing in the remaining four countries.

The above observations are reflected in the variance decomposition of unemployment, as labor demand shocks reign in short-run, which is consistent with Balmaseda, Dolado and Lopez-Salido (2000) results for a range of OECD countries. These shocks remain prevalent determinants of unemployment variability in longer term in Estonia, Latvia, and Slovakia. In Poland and Lithuania, however, innovations in wages become dominant as soon as after 2 years. In the next section we argue that this is mainly due to wage rigidities, that were binding when labor markets faced downward pressures on wages induced by other shocks.

In Baltic states, Poland and Slovakia, importance of shocks in trade with CIS countries is indeed revealed in variance decompositions, however Slovakia is the only country where disturbances in EU15 exports explain a non-negligible fraction of unemployment and employment variability. Nevertheless, the long-lasting contribution of both foreign demand shocks, should in our opinion be perceived as a small sample phenomena.[22]

# 4 Relative contribution of shocks and rigidities to NMS labor markets' performance

## 4.1 Retrospective SVECM simulations

The estimated SVECM allows to extract from the data, for all countries in the panel, series of pairwise orthogonal structural shocks. Estimation of the Beveridge-Nelson representation of cointegrated stochastic proces[23] enables to express the evolution of each variable as a MA process contingent on these identified structural disturbances. It allows also to conduct thought experiments in which the hypothetical evolution of analyzed economies, provided that given shocks did not occurred in selected subperiods, is simulated.[24]

[21] In Czech Republic productivity exerts similar influence, in line with strong responses of employment and unemployment to productivity shocks in this country (Figure 5).

[22] Correspondingly, importance of CIS shocks for employment and unemployment variance in Czech Republic is due to the identification error - Czech Republic's economic ties with CIS countries has been relatively small. It suffered its own currency crisis, which is not controlled explicitly, roughly at the time of Russian crisis. Hence the spurious influence of shocks in trade wit CIS on Czech labor market.

[23] See equation (10) in section 2.1.

[24] The reader may be familiar with similar analysis presented by Blanchard and Quah (1989) for US economy. However, our method differs as SVECM is used and certain identified shocks are set to zero only in chosen subperiods.

These experiments make possible the assessment of the relative importance of specific shocks for the evolution of CEE labor markets in the 1996-2007 period. The focus is on fluctuations of external demand and labor demand shocks, as the literature (eg. Paas and Eamets, 2006; Bukowski and Lewandowski, 2006; various OECD country studies) hinted at importance of such disturbances for developments of CEE labor markets in the analyzed period. Impulse responses presented in previous section suggest that they indeed might have been a primary force in these evolutions. Additionally, the interactions between these "primary" shocks and innovations in wages (interpreted as rigidities) are analyzed in order to assess their relative importance. Results are presented in the Figures $11 - 13$.[25]

Counterfactual evolutions conditioned on all structural disturbances in external demand fluctuations "turned off" (Fig. 11), disclose that these shocks had only marginal impact on the NMS8 labor markets.[26] Countries like Latvia, Hungary or Slovenia remained practically intact by disturbances in fluctuations of foreign demand. In case of Czech Republic, Estonia and Lithuania, the repercussions of these shocks were relatively small.[27]

Poland and Slovakia are two notable exceptions. As visible on Figures 11 and 12, the Russian crisis caused in Poland one percentage point fall in employment rate and relevant rise in unemployment in 1998-1999, which have propagated until the end of the analyzed period. On the other hand, Slovakia stands out as the only labor market positively affected by EU15 demand shocks, which dominated over the negative impact evoked by the Russian crisis.[28]

It seems, however, that the behavior of wages might have been the crucial factor behind contrasting performance of NMS labor markets early in the decade. Figures 12 and 13 present the hypothetical evolutions of unemployment, provided no disturbances in demand from CIS in 3q1998-2q1999, and no labor demand innovations during the year 2000 respectively, occurred. In both experiments these shocks are also interacted with innovations to real wages identified for the same subperiods. We interpret positive wage shocks identified parallel to other shocks depressing employment as downward real wage rigidities.

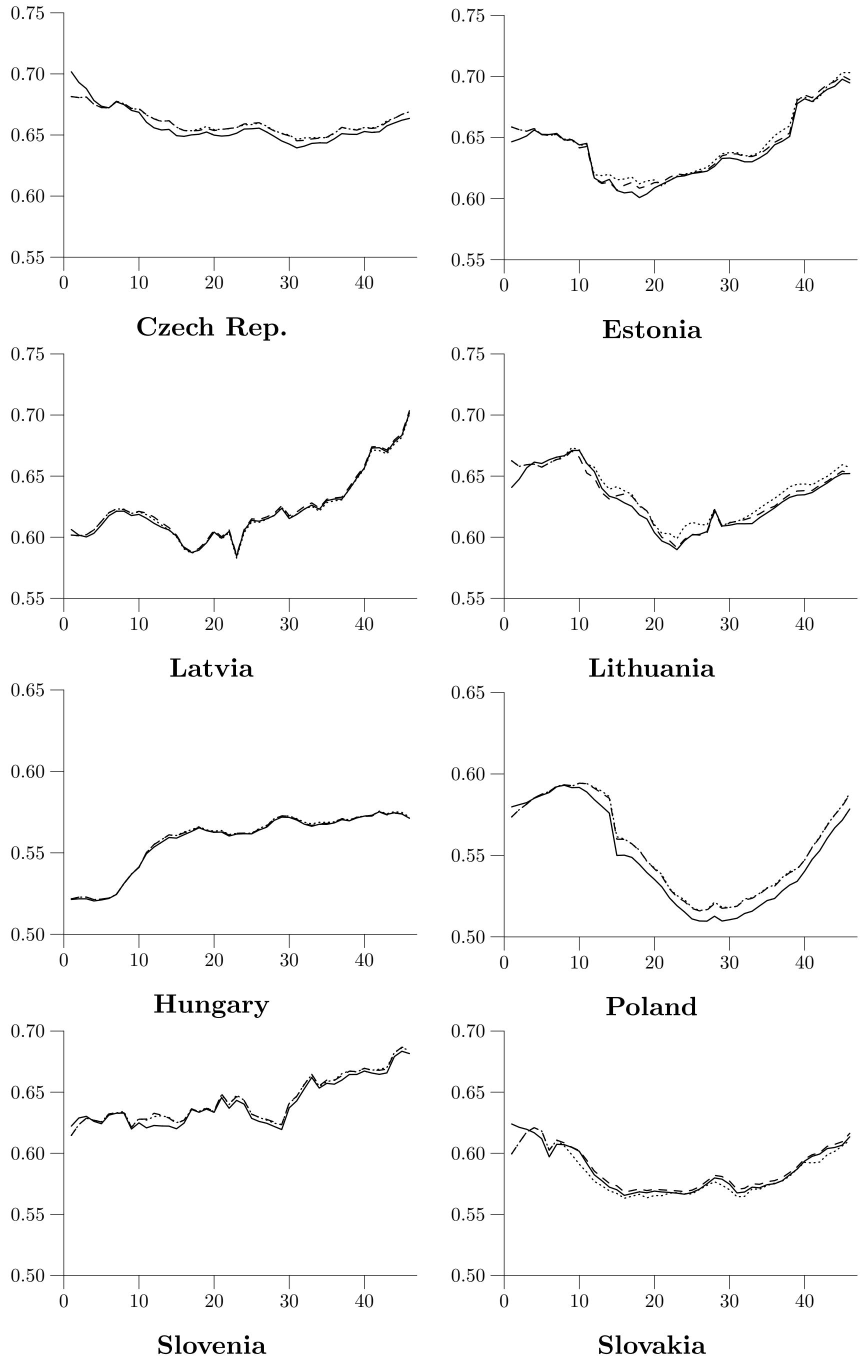
[25] To reduce the risk of bias caused by potentially inaccurate identification of shocks at the beginning of the sample,which can be contaminated by the cumulated disturbances from pre-sample period, simulations start in the ninth quarter in the sample (1q1998).

[26] Remember that we do not extract from the data the business cycle, as would be the case if exports were treated as exogenous variables.

[27] Although the model attributes the increase in Czech unemployment in 1998 to the collapse of Russian imports, it is likely a misidentification, as explained in previous section.

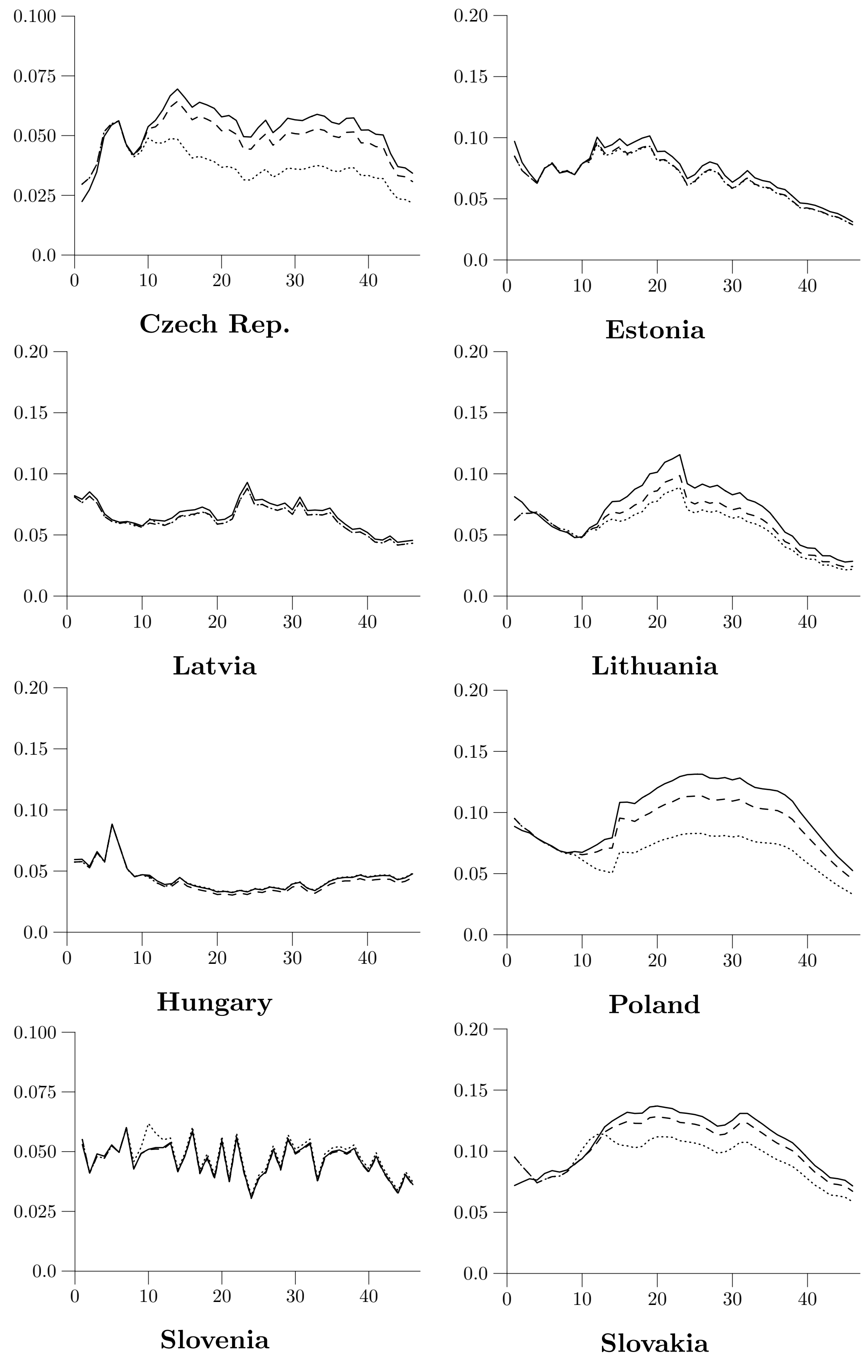
[28] Indeed, the share of EU15 exports in Slovakia GDP jumped from 25 per cent in 1997 to 42 per cent in 1999, substantially overbalancing slump of demands from CIS and Czech Republic alike.

**Figure 11: Impact of foreign demand shocks on employment in NMS (3q1996-4q2007)**



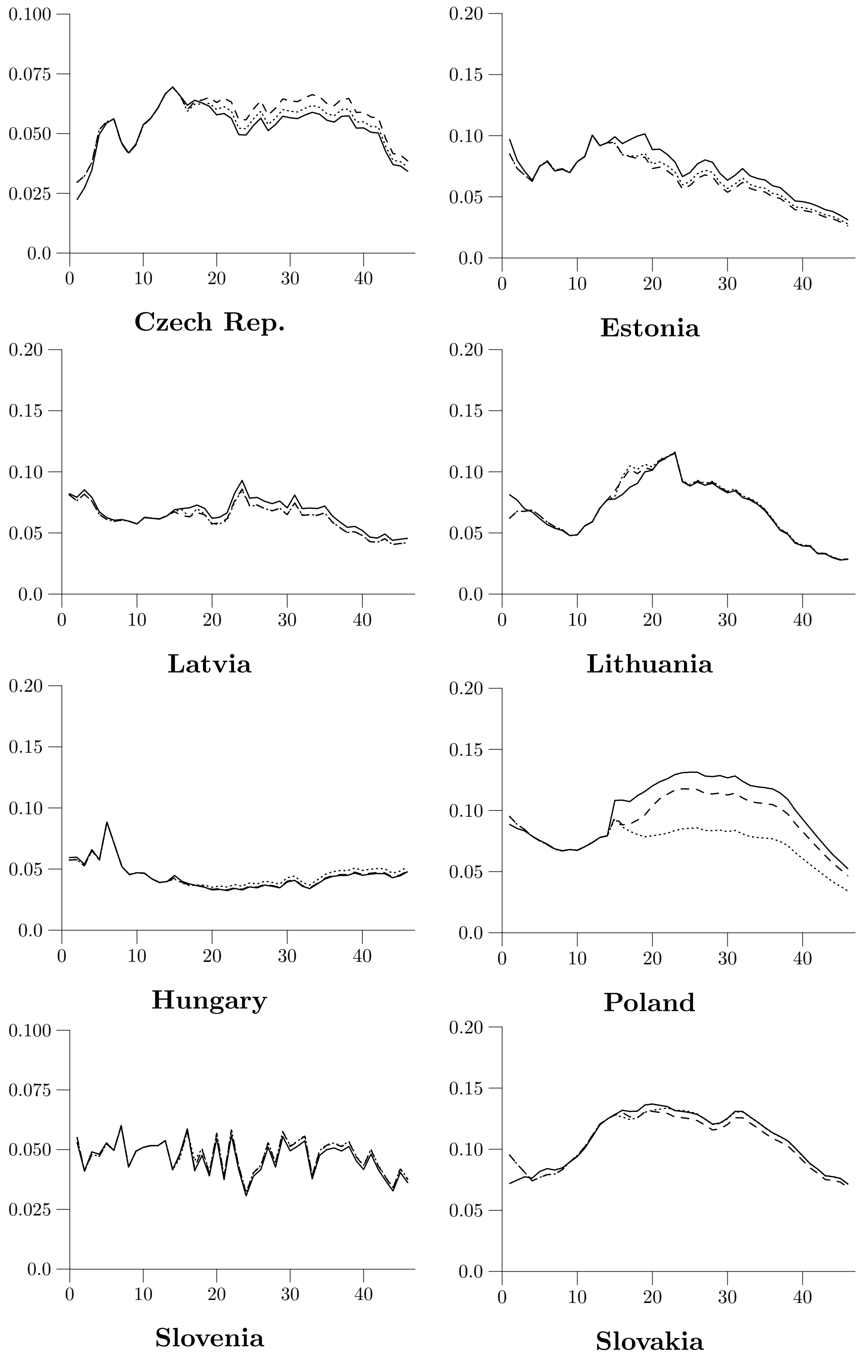

solid line – observed evolution of employment rate; dashed line – hypothetical evolution of employment rate provided no shocks in trade with CIS occurred between 1q1998and 4kw2007; dotted line – hypothetical evolution of employment rate provided no shocks in trade with CIS and in trade with EU15 occurred between 1q1998 and 4q2007.

**Figure 12: Impact of foreign demand shocks and innovations in wages between 3q1998 and 2q1999 on unemployment in NMS (3q1996-4q2007)**




solid line – observed evolution of unemployment indicator; dashed line – hypothetical evolution of unemployment indicator provided no shocks in trade with CIS occurred between 3q1998and 2q1999; dotted line – hypothetical evolution of unemployment indicator provided no shocks in trade with CIS and no wage shocks occurred between 3q1998and 2q1999.

**Figure 13: Impact of labor demand shocks and innovations in wages between 1q2000 and 4q2000 on unemployment in NMS (3q1996-4q2007)**




solid line – observed evolution of unemployment indicator; dashed line – hypothetical evolution of unemployment indicator provided no labor demand shocks occurred between 1q2000 and 4q2000; dotted line – hypothetical evolution of unemployment indicator provided no labor demand shocks and no wage shocks occurred between 1q2000 and 4q2000.

Simulations show that in Poland, Slovakia and Lithuania, as well as Czech Republic, wage rigidities seem likely to have intensified the negative impact of the Russian and Czech crises respectively. If the wages adjusted flexibly to increasing unemployment after these "primary" shocks occurred, unemployment would have been significantly lower than the recorded levels. Contrastingly, although in case of Estonia detect some positive influence of the Russian crisis on unemployment is detected (see Figure 12), there is no additional pressure from inflexible wage arrangements.[29]

This feature seems to be particularly harmful to Polish labor market, as Figure 13 illustrates. The model indicates that substantial, lasting few quarters, negative labor demand shock occurred in Poland in 2000. According to the results, it is however responsible for about half of the rise of unemployment between 2000 an 2003. The comparable share of this unemployment increase is attributed to positive wage shocks. We interpret these shocks as downward real wage rigidities in the aftermath of employment contraction. Noticeably less ample and short-lived contribution of wage rigidities intensifying drop in labor demand, is identified by the model in Latvia and Slovakia. On the other hand, Estonia emerges as the country where flexible wages helped to suppress unemployment.

## 4.2 Synthetic measurement of wage rigidities and flexibility of NMS8 labor markets

A final exercise is to measure wage rigidities and flexibility in response to shocks on NMS labor markets in the 1996-2007 period. We follow seminal contributions of Nickell et al. (1991) and Balmaseda, Dolado and Lopez-Salido (2000), who put forward and calculated indices of wage rigidities for OECD countries. However, contrary to these authors, measures proposed in this paper build on ability of the economy to restore the cointegration-consistent equilibrium level of real wages, provided that specific structural disturbance occurred. Moreover, the measure of flexibility is calculated on the basis of propagation of productivity shock.

The rationale behind wage rigidity measures is as follows. According to cointegration relation (12), wages are the outcome of "empirical equilibrium" interpreted as wage-setting function, and long-run restrictions (13) imply that real wage shocks unsettle the cointegration-consistent level of wages only temporarily. Since various shocks may interact with wage setting diversely,[30] we postulate that the longer it takes wages to restore the equilibrium level after a given shock, the higher the wage rigidity with re-

[29]Indeed, Paas, Eamets (2006) study flexibility of wages at national and sectoral in Baltic states after the Russian crisis, and argue that Lithuania seems to had more rigid wages than Estonia and Latvia.

[30]For example, strong insider-outsider effects may prolong adjustment of wages to labor supply shocks, but their presence do not imply that wage shocks *per se* become persistent.

spect to this shock is. So the model is simulated conditional on only one structural endogenous shock being present in the data, and the average time needed for wages to return to cointegration-consistent level is calculated. As the obtained values, denoted as $WRI^k_{\xi^X}$, where $X \in \{Y, N, V, W\}$ represents shocks as in section 1 and $k$ stands for country, are ambiguous to interpret and the concept of rigidity is inherently relative, they are normalized within the sample using the standard formula

$$wri^k_{\xi^X} = \frac{WRI^k_{\xi^X} - WRI_{min}}{WRI_{max} - WRI_{min}} \tag{15}$$

so $\forall_k wri^k_{\xi^X} \in [0, 1]$ and higher value means stronger rigidity.

Then the distinction between $wri_{\xi^W}$, which measures the persistence of wage shocks, and $wri_{AV}$ which measures the ability of real wages to restore equilibrium when the economy is affected by three other endogenous shocks, is made. $wri^k_{AV}$ is defined as

$$wri^k_{AV} = \frac{1}{3} \sum_{X \in \{Y,N,V\}} wri^k_{\xi^X}$$

and interpreted as a composite measure of rigidity of wage adjustments to shocks.

Measurement of the another margin of flexibility is also proposed. Positive productivity shocks lead to transitory unemployment increases and long-term improvements in output per worker and average real wages (see Figure 5) in all NMS. We suppose that, given the long-run increase in average real wages, which approximates welfare gain, the lower the cumulated rise in unemployment, which approximates welfare loss, (i) the better the net balance between destruction and capitalization effects, and (ii) the more flexible reallocation of production factors is (see Caballero, 2007).

As the long-term response of average wages differs within the panel, a natural definition of "reallocation flexibility index" is as follows

$$RFI^k = \lim_{j \to \infty} \frac{\sum_0^\infty \partial u^k_{t+j} / \partial \xi^Y_t}{\partial w^k_{t+j} / \partial \xi^Y_t} \tag{16}$$

which is the cumulated impact of productivity shock on unemployment per unit of long-term real wages gain in country $k$.[31] $RFI^k$ are normalized according to (15) to obtain $rfi^k \in [0, 1]$, higher value means lower flexibility.[32]

[31] Both unemployment indicator and average real wages are in logs, so nominator and denominator are expressed as relative changes after the shock.

[32] Construction of this index was proposed by Balmaseda, Dolado and Lopez-Salido (2000), who treated it as a wage rigidity index. We think that interpretation as a measure of ability to reallocate production factors after productivity shock is better-founded.

Table 5: Wage persistence, wage rigidity and reallocation flexibility indices

| Country | $wri_{\xi^W}$ | $wri_{AV}$ | $rfi$ |
|---|---|---|---|
| Czech Rep. | 0.09 | 0.35 | 1.00 |
| Estonia | 0.11 | 0.36 | 0.36 |
| Latvia | 1.00 | 0.72 | 0.00 |
| Lithuania | 0.39 | 0.68 | 0.38 |
| Hungary | 0.34 | 0.18 | 0.34 |
| Poland | 0.16 | 0.63 | 0.21 |
| Slovenia | 0.00 | 0.03 | 0.06 |
| Slovakia | 0.24 | 0.14 | 0.08 |

$wri_{\xi^W}$ - real wage shocks persistence index; $wri_{AV}$ - composite index of real wage rigidity with respect to labor productivity, demand and supply shocks; $rfi$ - flexibility of reallocation index. All indices calculated on the basis of panel SVECM and normalized according to (15). $wri_{AV}$ is an average of $wri_{\xi^X}$, $X \in \{Y, N, V\}$. Higher value means stronger rigidity.

Table 5 presents the calculated measures. Regarding wage adjustments, Latvia stands out with highest rigidities on both margins - persistency of wage shocks and adjustments of wages to other disturbances - and is followed by Lithuania. On the other hand, Slovenia fared best on both margins. Estonia was also characterized by flexible wage adjustments, especially when ability to counterbalance innovations in wages is concerned. The same applies to Czech Republic. Contrastingly, in Hungary, and to lower degree in Slovakia, capacity to adjust wages to "equilibrium" after productivity, labor demand and supply shocks was relatively greater than to accommodate innovations in wages. Finally, although in Poland persistence of wage shocks was quite low - only Slovenia, Czech Republic and Estonia score better - wage rigidities in the aftermath of other domestic disturbances were eminent, especially conditional on labor demand shocks.[33]

The reallocation flexibility index $rfi$ suggests that the welfare cost of reallocation adjustments, ie. short-run net destruction of jobs per unit of long-run gain in real average wages stemming from productivity shock, was highest in the Czech Republic. The main factor behind this result is a substantial initial response of unemployment to such shock, but the estimated long-term gain in output per worker and wages in this country is also quite low (see Figure 5). Slovenia, Slovakia and Latvia are found to most flexible, mainly thanks to moderate initial unemployment spikes in unemployment.[34] According to the index, reallocation flexibility of Estonian economy is close to the one of Lithuanian and Hungarian, although Estonia fares much better when it comes to wage rigidities. Poland is characterized by a rather moderate "opportunity cost" of unemployment increases after productivity shocks.

[33]On the basis of $wri_{\xi^N}$, result we do not show here.

[34]Contrasting values of wage rigidity indices and reallocation flexibility index in Latvia deserve some caution. In the panel setting, wage shocks' consequences in Latvia might be overestimated and productivity shocks be underestimated. We were however not able to test this conjecture explicitly.

## Conclusions

In this paper the dynamic responses of labor markets to macroeconomic shocks in eight CEE countries are empirically analyzed in panel SVECM. Identification of shocks, thought of as real wage, productivity, labor demand and supply shocks, is based on DSGE model with labor market explicitly modeled in a search-and-match block after Mortensen and Pissarides (1994). Fluctuations in foreign demand are used as controls for cross-section dependence, and are accounted for in a *quasi-exogenous* way. The model is estimated with panel procedure, which constitutes a slight modification of Breitung (2005) method. It brings estimation's precision, which exceeds the level achievable in small sample of quarterly data 1996-2007 via traditional country-by-country estimation.

The main goal of the paper is to quantify propagation of macroeconomic shocks on NMS8 labor markets in 1996-2007, and pinpoint those, that were crucial for the factual evolution of these markets. The analysis shows that responses to shocks of these markets fairly resemble mechanisms described in the literature studying OECD countries. In particular, (positive) labor demand shocks generally increase employment, depress unemployment, and, except for Latvia and Slovenia, rise real average wages. Labor demand shocks were found to be the main determinant of variability of employment and unemployment in the short-run. Differences emerge in the medium term, as demand shocks were found to be dominant in Estonia, Hungary, Slovakia and Slovenia, whereas in Czech Republic, Latvia, Lithuania and Poland innovations in wages seem to be prevalent.

The impact of disturbances in foreign demand fluctuations was moderate in most NMS, although Baltic states and Poland were significantly affected by the collapse of Russian exports in late 1990s. On the other hand, Slovakia stands out as the only NMS8 economy notably influenced by shocks in exports to EU15. Responses of NMS8 labor markets to productivity shocks are found to be highly similar to responses in OECD countries, with destruction effect of productivity improving shocks prevailing over capitalization effect in the short-run, thus temporarily rising unemployment. Such shocks, however, were not the crucial factors governing evolution of CEE labor markets in the period studied.

The retrospective simulations of the model suggest that central role was played by labor demand shocks. In some countries they were accompanied by foreign demand disturbances, and in some, not exactly the same ones, intensified by wage pressures. The most profound episode of rising unemployment, and widening heterogeneity among NMS labor markets, was triggered by contraction of Russian exports during 1998/1999. We found, however, that what distinguishes Estonia and Latvia from Lithuania, Poland and Slovakia at that time, is not the severity of the primary impulse, but rather flexibility of wage adjustments - rigidities in the latter group intensified detrimental impact of exports' decline. The same applies to Czech Republic adjustments after its 1997' currency crisis.

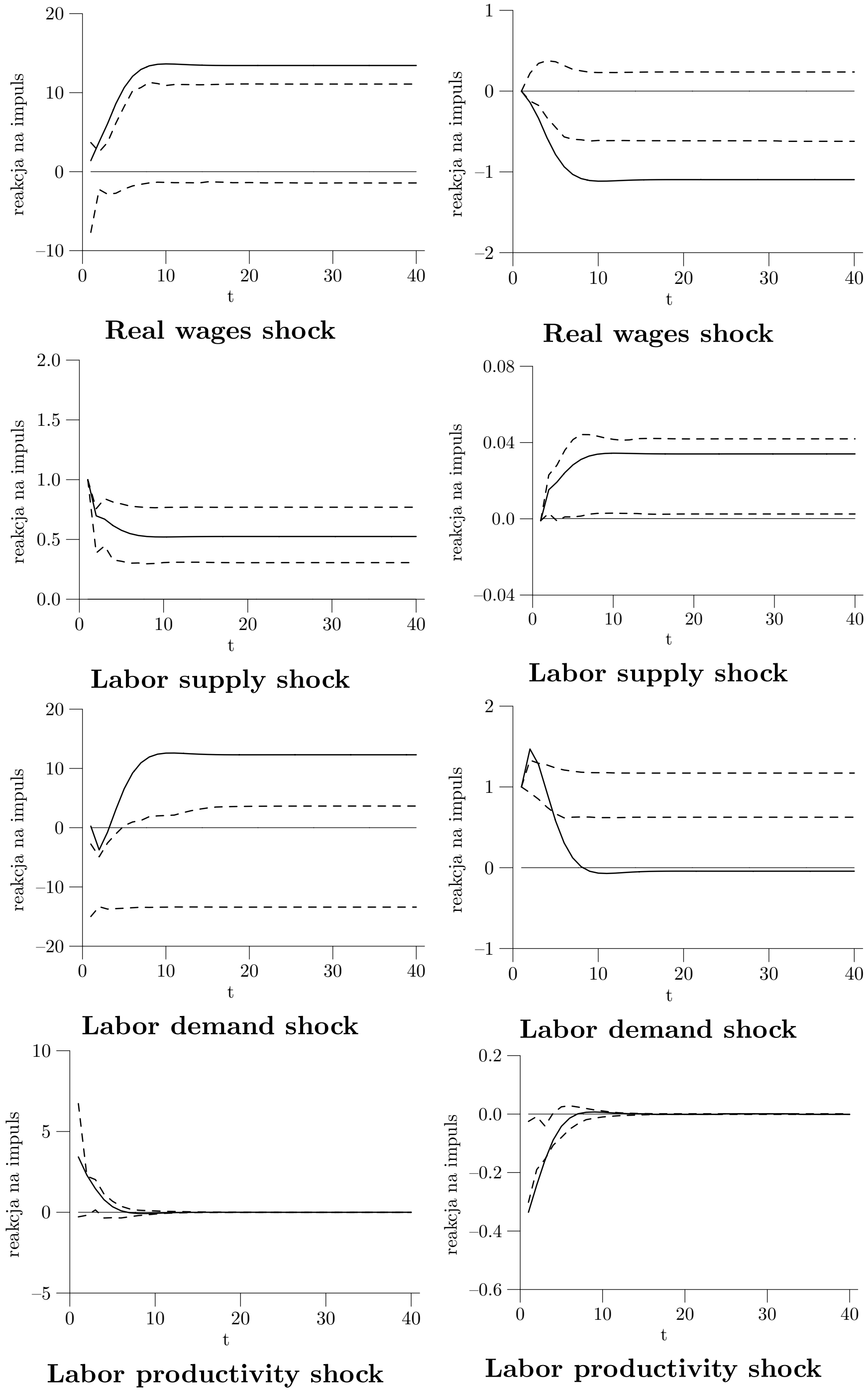
NMS8 labor markets receded further from each other between 2000 and 2003. The analysis indicates that it was mainly due to negative labor demand shocks, which occurred in 2000 and spanned few quarters. They affected all countries except Hungary and Slovenia. Their impact was most harmful in Poland. And so were downward wage rigidities at that time, which contributed to the surge in Polish unemployment in 2000-2003 to a similar degree as the shrinking labor demand. Slovakia and Latvia also suffered from insufficient wage adjustments, but to noticeably lower degree.

It seems that the sequence of adverse shocks explains a fair share of differences among CEE countries' labor market performance in 1996-2007 period - Slovenia and Hungary were not affected by so severe disturbances like Baltic states, Slovakia and Poland. However, adjustment mechanisms in form of wage flexibility influenced individual countries' performance - they distinguish between Latvia and Lithuania response to Russian crisis; between Estonia and Poland reaction to labor demand contraction in 2000. Some countries were able to learn their lessons - insufficient wage flexibility intensified adverse shock in Slovakia in 1998/1999, but did not as soon as in 2000. Indeed, the synthetic measures of wage rigidities indicate that Slovenia and Estonia fared best when it comes to flexibility of wages on macro level. In Hungary and Slovakia ability to adjust wages in the aftermath of other shocks was higher than to neutralize autonomous wage pressures. On the other hand, in Czech Republic, Lithuania and Poland rigidities were binding especially after employment-contracting shocks.

The question is then about the institutional determinants of these rigidities. It is obviously a tough one. Slovenia, with its more-than-decent labor market history and macro-flexibility, has been the most unionized country among NMS and fared poorly in competitiveness rankings. Baltic republics have improved considerably in last few years when business climate, taxation, and public spending are considered. Slovakia followed suit. Czech Republic, Hungary and Poland have more matured product markets and less restrictive employment protection legislation than Baltics and Slovakia, but on the other hand, exhibit higher barriers of entry and run taxation-social security systems which discourage from work. The preliminary suggestion is that high taxation and passive labor market policy may jointly explain wage rigidities found in Poland. Drawing on Blanchard (2006), it is worth stressing that although the future shocks are not known, the need for flexibility of wages even increases with prospects of joining the Eurozone.

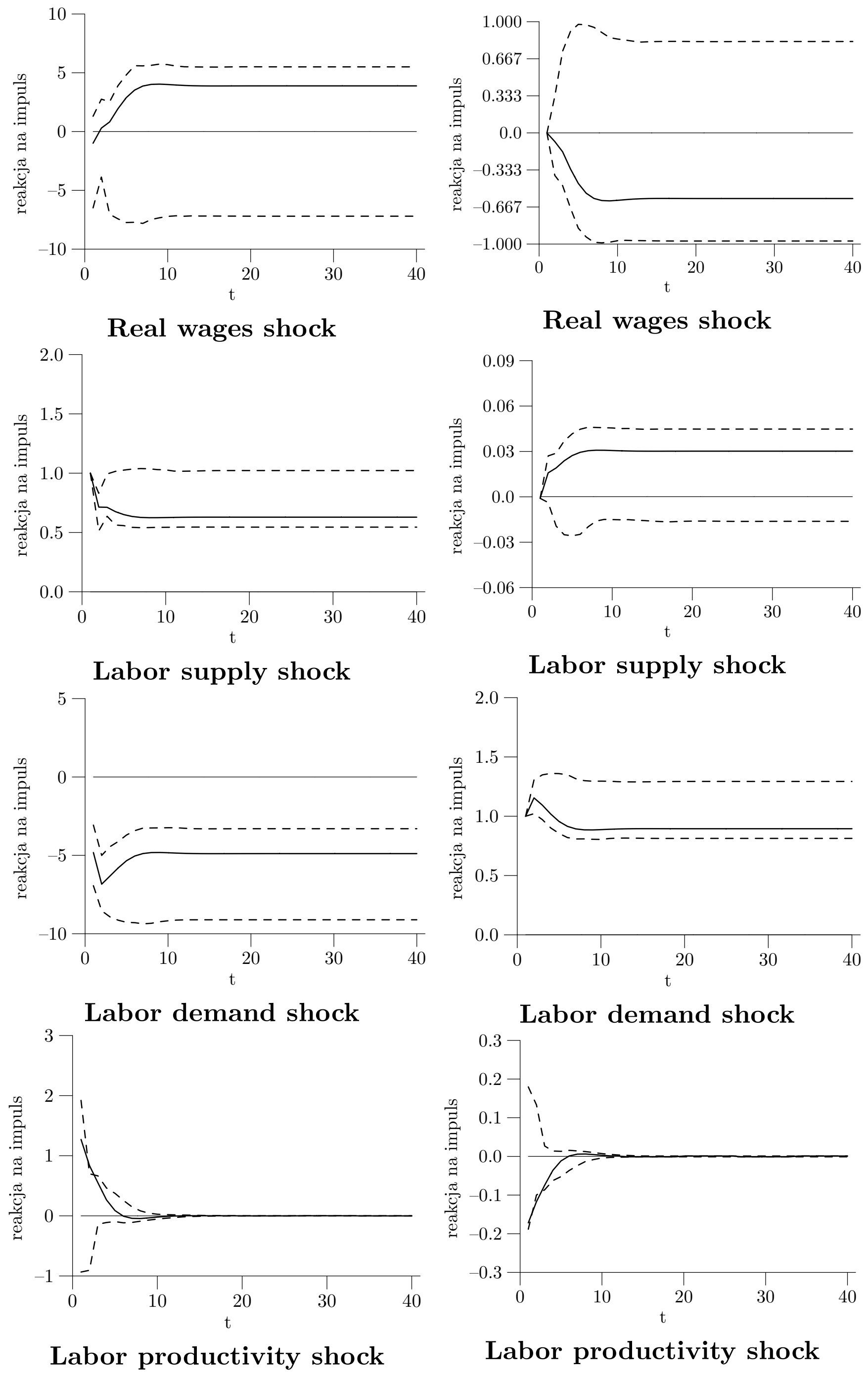
# A Impulse response functions with bootstrap confidence intervals

**Figure 14: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Czech Republic, with confidence intervals.**



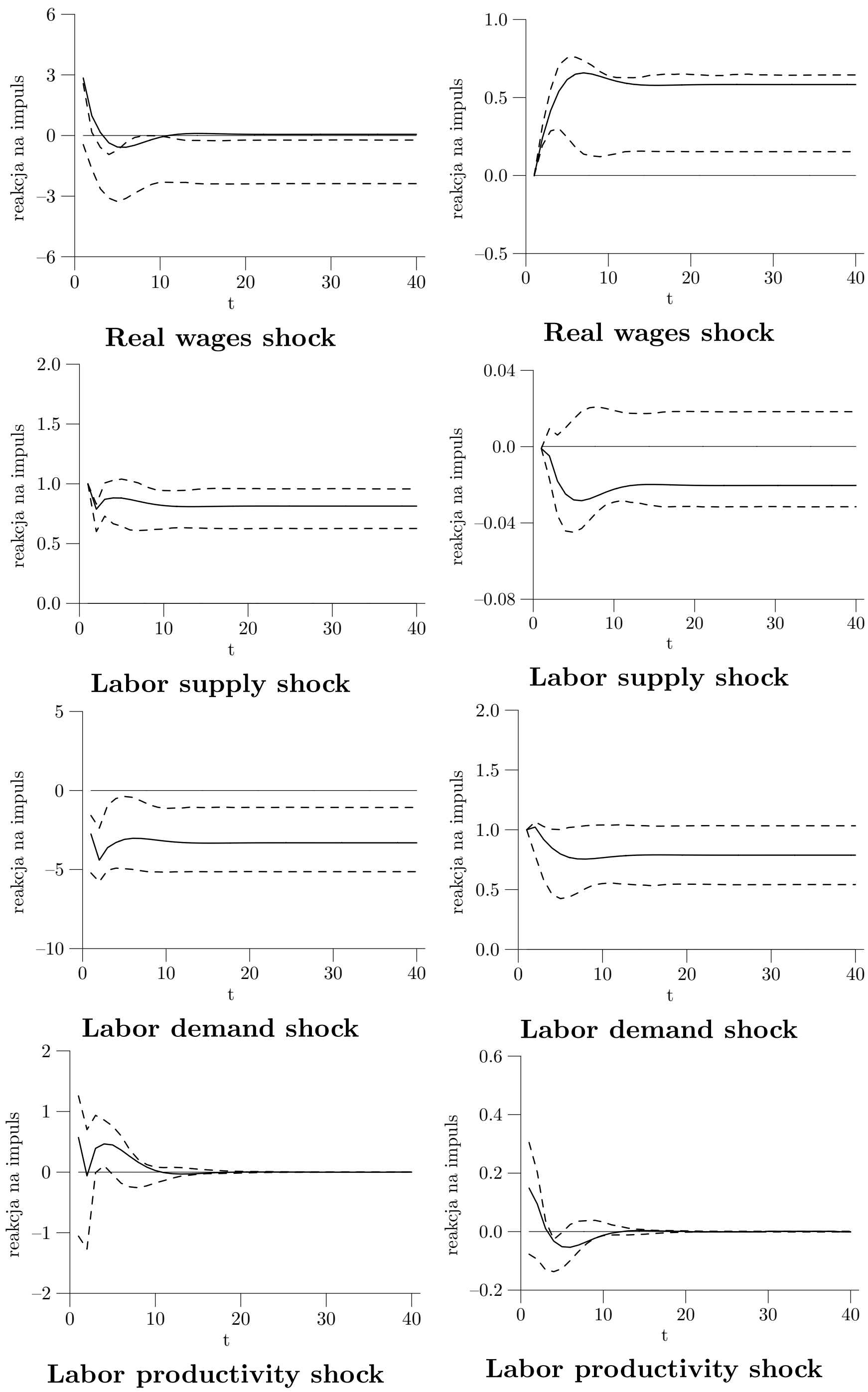

Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 15: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Estonia, with confidence intervals.**



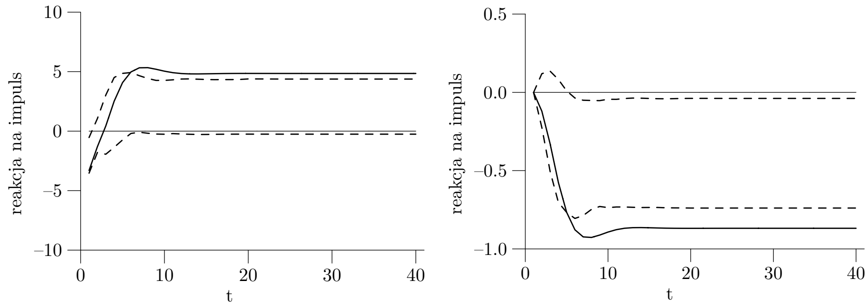

Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 16: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Latvia, with confidence intervals.**

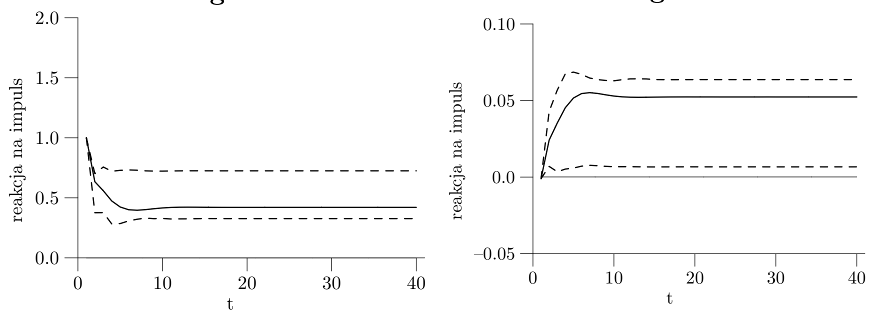



Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

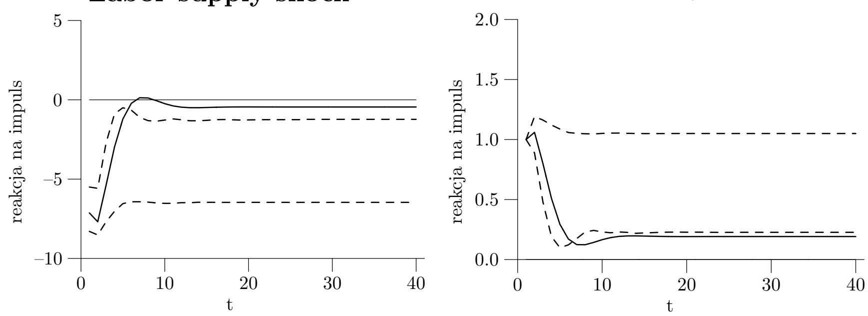
**Figure 17: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Lithuania, with confidence intervals.**



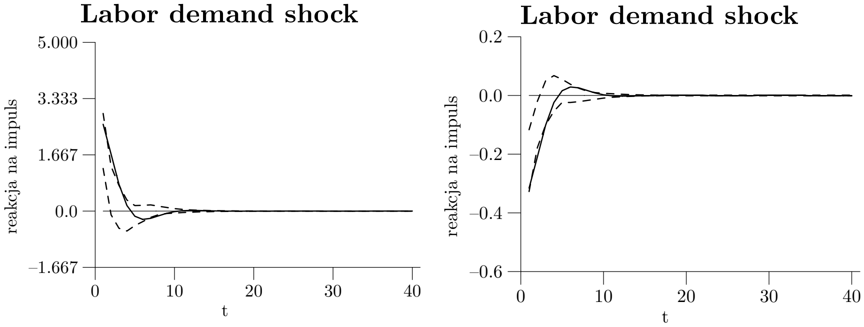

**Real wages shock** **Real wages shock**




**Labor supply shock** **Labor supply shock**



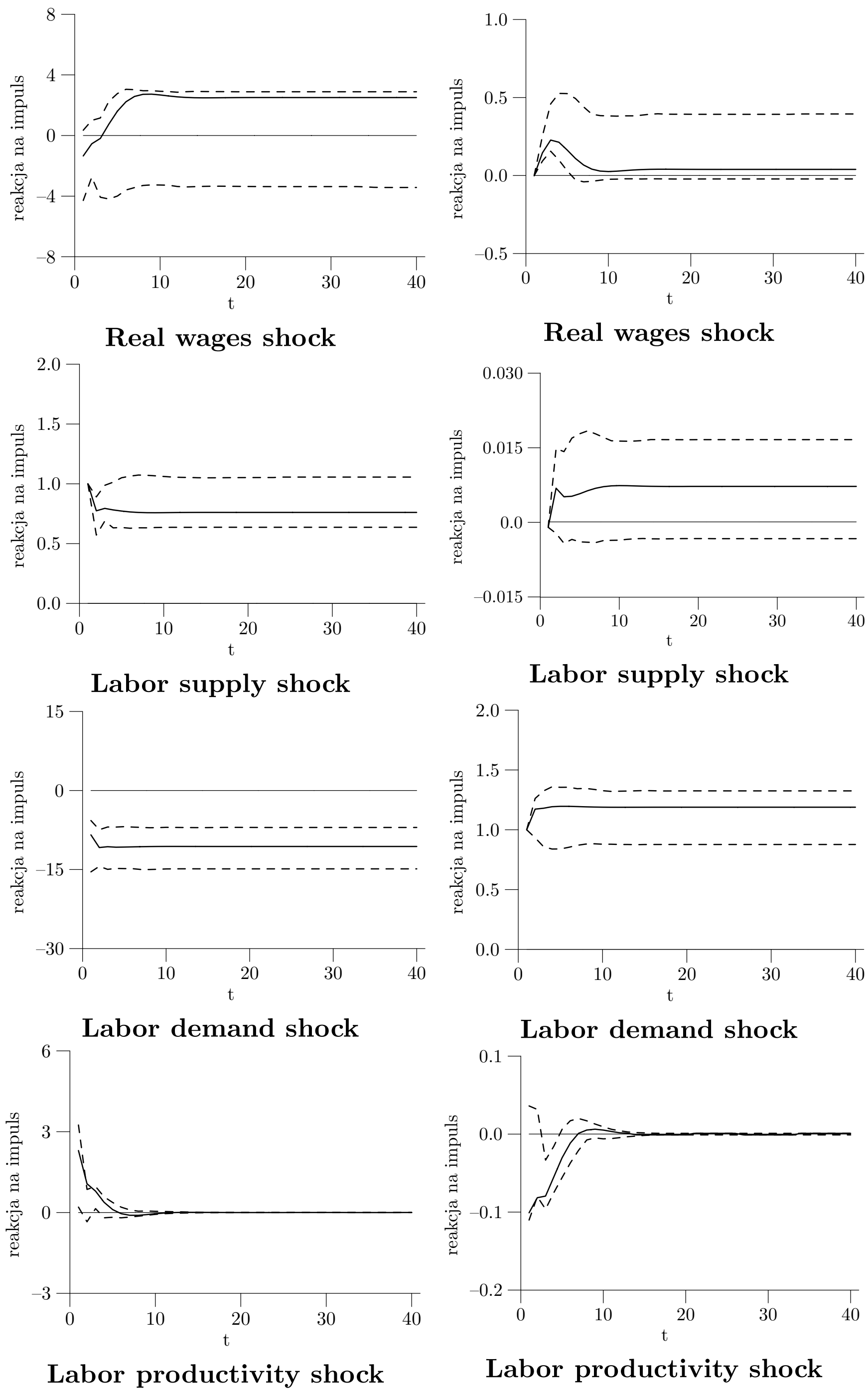

**Labor demand shock** **Labor demand shock**




**Labor productivity shock** **Labor productivity shock**

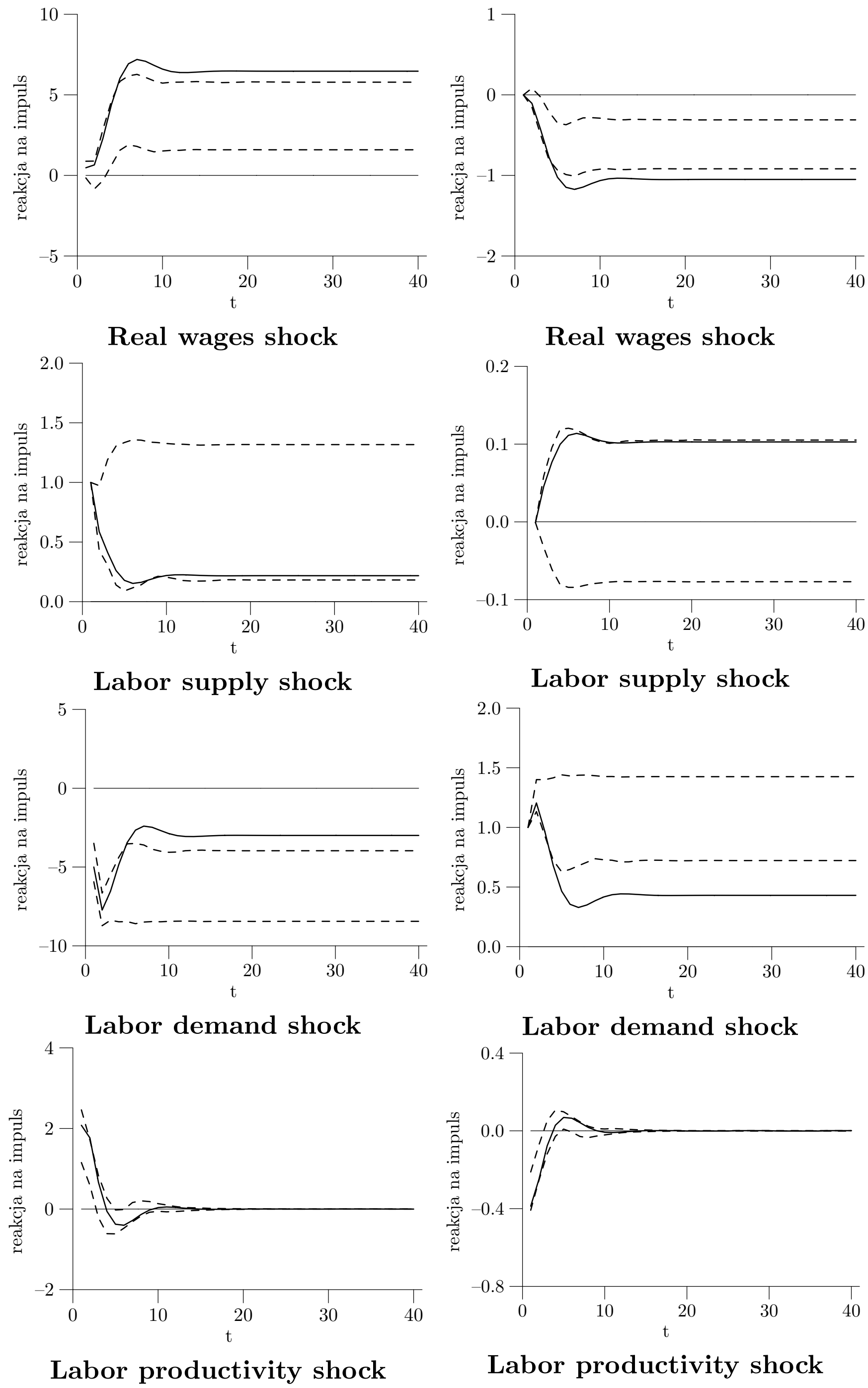
Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 18: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Hungary, with confidence intervals.**



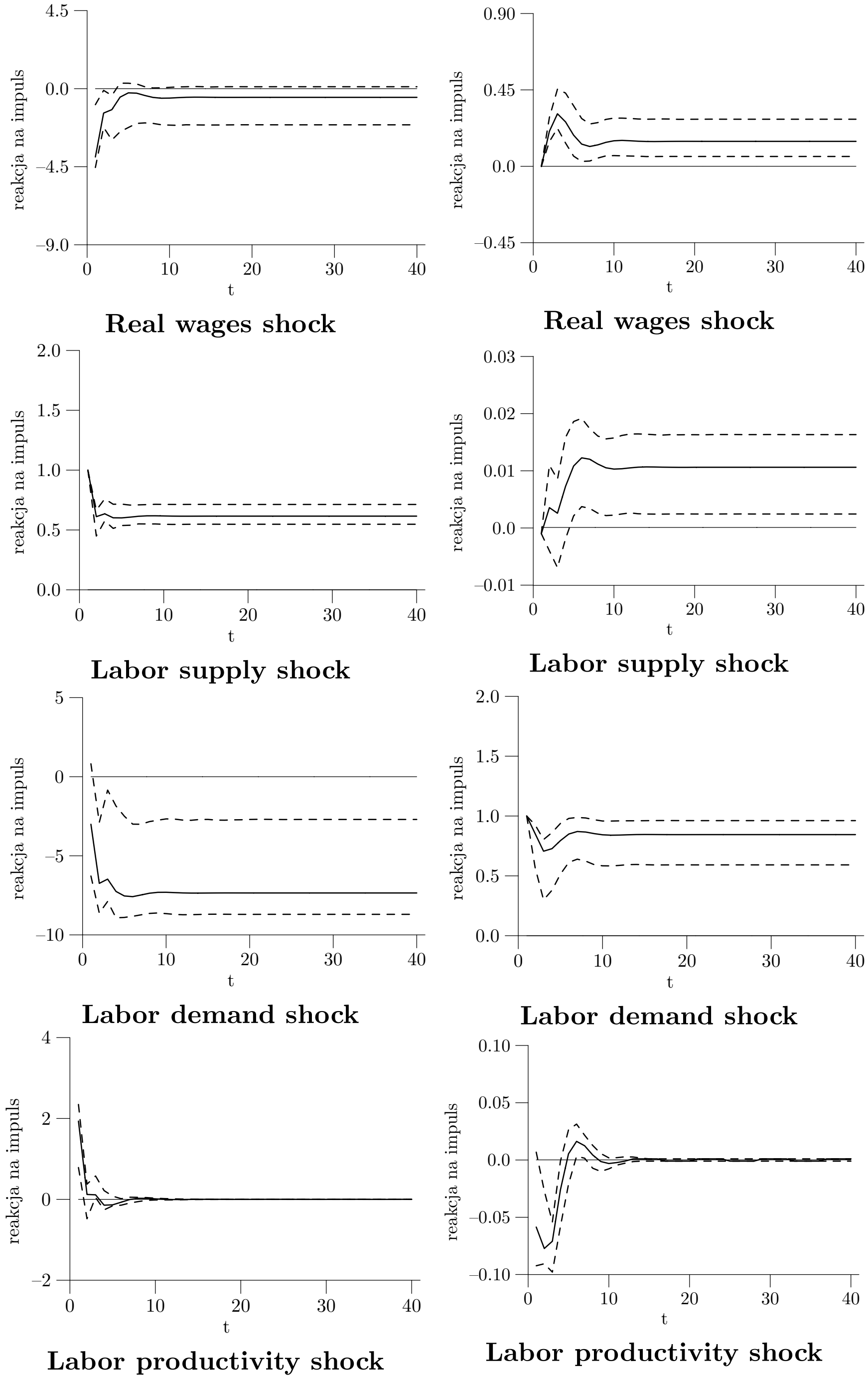

Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 19: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Poland, with confidence intervals.**



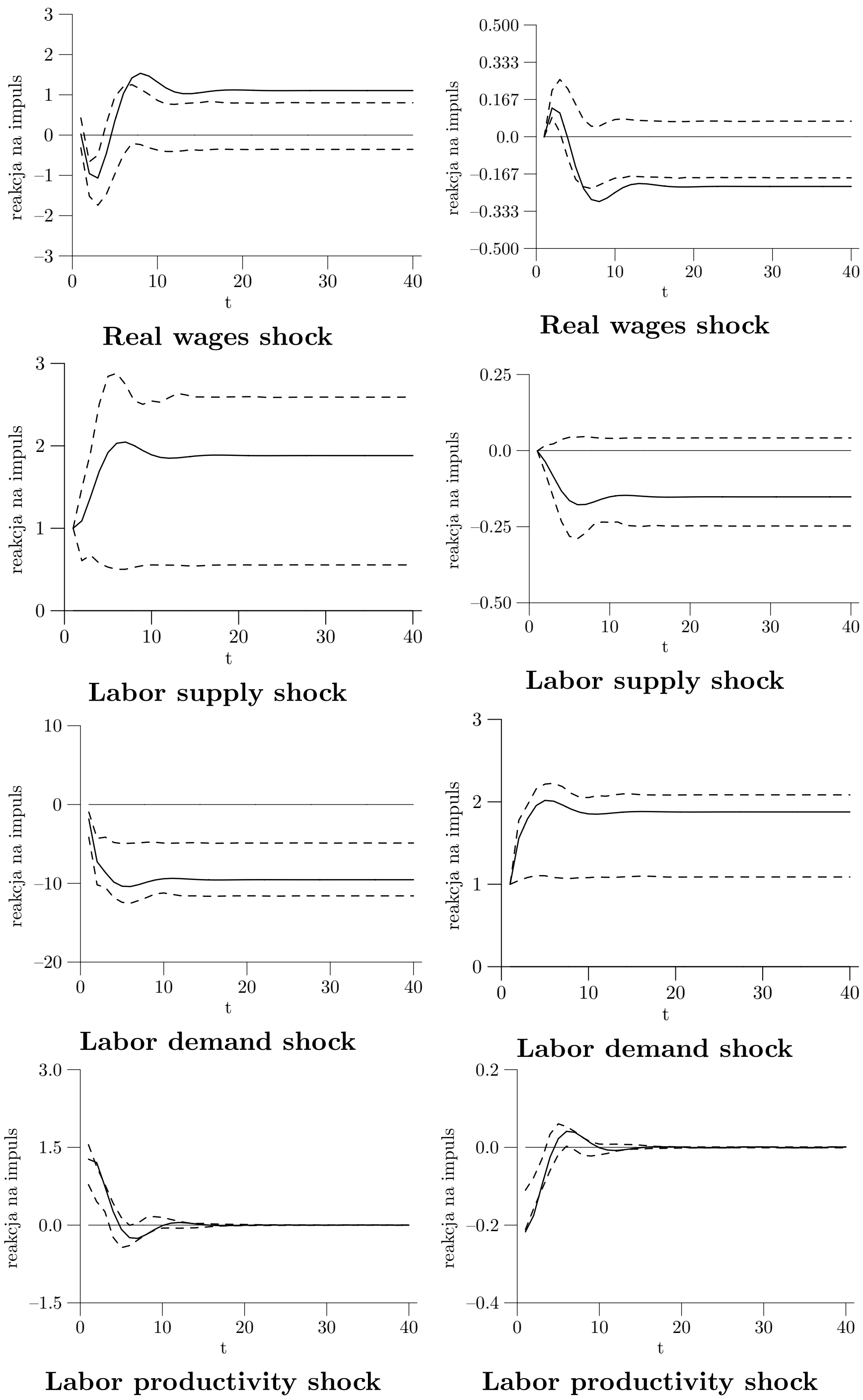

Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 20: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Slovenia, with confidence intervals.**



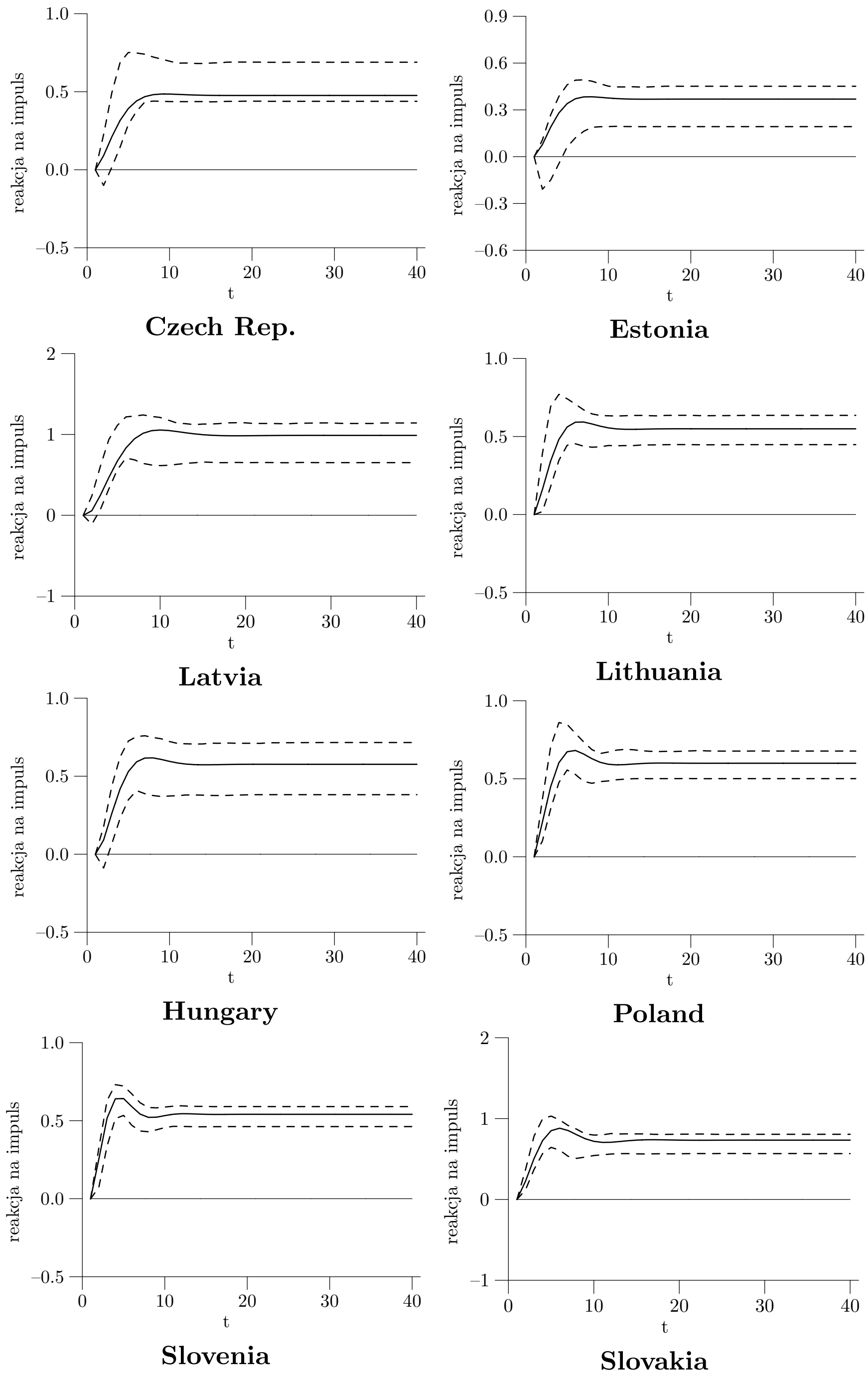

Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 21: Impulse response functions of unemployment (left panel) and employment (right panel) to structural shocks in Slovakia, with confidence intervals.**



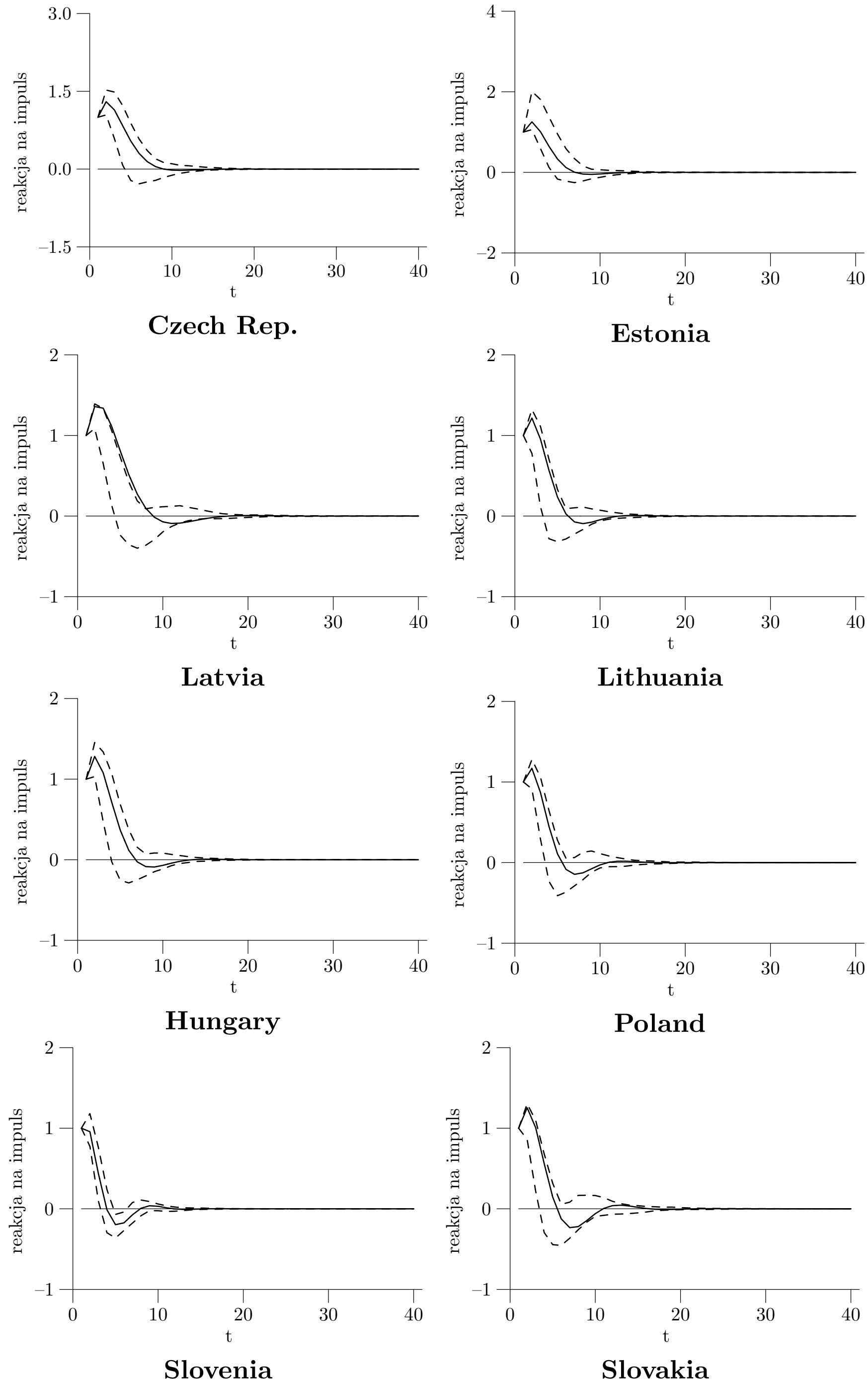

Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 22: Impulse response functions of real wages to labor productivity shock in NMS8, with confidence intervals.**




Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

**Figure 23: Impulse response functions of real wages to innovation in real wage setting in NMS8, with confidence intervals.**




Solid line – IRF; dashed lines – 90 percent confidence interval computed from 500 bootstrap simulations.

## References

Ahn S.K., Reinsel G.C., (1990), Estimation for Partially Nonstationary Multivariate Autoregressive Models, Journal of the American Statistical Association, 85, p. 813-823.

Aghion P., Howitt P., (1994), Growth and unemployment, Review of Economic Studies, 61

Altig D., Christiano J., Eichenbaum M., Linde J., (2005), Firm-Specific Capital, Nominal Rigidities and the Business Cycle, NBER Working Paper no. 11034.

Amisano G., Giannini C., (1997), Topics in Structural VAR Econometrics, 2nd ed., Springer, Berlin.

Balmaseda M., Dolado J., Lopez-Salido J. D., (2000), The Dynamic Effects of Shocks to Labour Markets: Evidence from OECD Countries, Oxford Economic Papers, Oxford University Press, vol. 52(1), p. 3-23.

Bassanini A., Duval R., (2006), Employment patterns in OECD countries: reassessing the role of policies and institutions, OECD Economics Department Working Paper 486.

Bean Ch. Pissarides Ch., (1993), Unemployment, consumption and growth, European Economic Review, Elsevier, vol. 37(4), p. 837-854.

Bean C.R. (1994), European unemployment: A survey, Journal of Economic Literature, 32, p. 573-619.

Blanchard O., (2005), European Unemployment: The Evolution of Facts and Ideas, NBER Working Paper No. 11750.

Blanchard O., (2006), Adjustment with the Euro: The Difficult Case of Portugal, MIT Department of Economics Working Paper No. 06-04.

Blanchard O., D. Quah (1989), The dynamic effects of aggregate supply and demand disturbances, American Economic Review, 79, p.655-673.

Blanchard O., Wolfers J., (2000), The role of shocks and institutions in the rise of European unemployment: the aggregate evidence, The Economic Journal, 110:C1-C33.

Breitung J., Brüggemann R., Lütkepohl H., (2004), Structural vector autoregressive modeling and impulse responses in: Applied Time Series Econometrics pod red. Lütkepohl H. i Krätzig , Cambridge University Press, Cambridge, p. 159-196.

Breitung J., Pesaran M.H., (2005), Unit Roots and Cointegration in Panels, Cambridge Working Papers in Economics 0535, Faculty of Economics, University of Cambridge

Breitung J., (2005), A Parametric Approach to the Estimation of Cointegration Vectors in Panel Data, Humboldt University Working Paper, Berlin.

Brüggemann R., (2006), Sources of German unemployment: a structural vector error correction analysis, Empirical Economics, Springer, vol. 31(2), p. 409-431

Brüggemann R., Lütkepohl H., (2004), Practical Problems with Reduced Rank ML Estimators for Cointegration Parameters and a Simple Alternative, Discussion Paper, European University Institute, Florence.

Bukowski M., Koloch G., Lewandowski P., (2007), Labour market macrostructure, shocks and institutions, in: Employment in Poland 2007, ed. Bukowski M., MPiPS, Warsaw 2007

Bukowski M., Lewandowski P., (2006), Labour market in macroperspective, in: Employment in Poland 2006, ed. Bukowski M., MPiPS, Warsaw 2006

Caballero R., (2007), Specificity and the macroeconomics of restructuring, MIT Press.

Camarero M., Carrion-i-Silvestre J., Tamarit C., (2006), Testing for hysteresis in unemployment in OECD countries. New evidence using stationarity panel tests with breaks, Oxford Bulletin of Economics and Statistics, Department of Economics, University of Oxford, vol. 68(2), pages 167-182, 04.

Dolado J.J., Jimeno J.F., (1997),The causes of Spanish unemployment: A structural VAR approach, European Economic Review, 41, p.1281-1307.

Fisher J., (2006), The Dynamic Effects of Neutral and Investment-Specific Technology Shocks, Journal of Political Economy, 2006, vol. 114, no. 3

Fortuny M., Nesporova A., Popova P., (2003), Employment promotion policies for older workers in the EU accession countries, the Russian Federation and Ukraine, ILO Employment Paper 2003/50

Gamber E., Joutz F., An Application of Estimating Structural Vector Autoregression Models with Long Run Restrictions, The Journal of Macroeconomics, September, 1993, vol. 15, 4, p. 723-745.

Hansen, P. H. (2000), The Johansen-Granger Representation Theorem: An Explicit Expression for I(1) Processes, Working Paper, US San Diego and Brown University

Hurlin C., (2004), Nelson and Plosser Revisited : A Re-Examination using OECD Panel Data, Laboratoire d'Economie d'Orleans, Document de Recherche 2004/23.

Jacobson T., Vredin A., Warne A., (1993), Are Real Wages and Unemployment Related?, Papers 558, Stockholm - International Economic Studies.

Jacobson T., Vredin A., Warne A., (1997), Common trends and hysteresis in Scandinavian unemployment, European Economic Review, Elsevier, vol. 41(9), p. 1781-1816.

Johansen S., (1995), Likelihood-based Inference in Cointegrated Vector Autoregressive Models, Oxford University Press.

Johansen K., (2002), Hysteresis in unemployment: evidence from Norwegian counties, Working Paper series no. 6/2002, Department of Economics, Norwegian University of Science and Technology.

Koloch G., Szufel P., (2008), Small Samples and Economic Reasoning, Wydawnictwo X Konferencji Polskiego Towarzystwa Badań Operacyjnych i Systemowych BOS

Layard R., Nickell S., Jackman R., (1991), Unemployment: Macroeconomic Performance and the Labour Market, Oxford University Press, Oxford.

León-Ledesma M., MacAdams P., (2003), Unemployment, Hysteresis and Transition, European Central Bank Working Paper no. 234.

Magda I., Szydowski A., (2007), Wages in macro- and micro-perspective, in: Employment in Poland 2007, ed. Bukowski M., MPiPS, Warsaw 2007.

Michelacci C., Lopez-Salido D., (2007), Technology Shocks and Job Flows, Review of Economic Studies, 74, p. 1195-1227

Moon H. R., Perron B., (2005),An Empirical Analysis of Nonstationarity in Panels of Exchange Rates and Interest Rates with Factors, IEPR Working Papers 05.35, Institute of Economic Policy Research (IEPR).

Mortensen D., (2005), Growth, Unemployment and Labor Market Policy, Marshall Lecture, presented at the European Economic Association Meeting, Madrid, August 24, 2004, Journal of the European Economic Association 3.

Mortensen D., Pissarides Ch., (1994), Job creation and job destruction in the theory of unemployment, Review of Economic Studies, vol. 61(3), p. 397-415

Myck M., Morawski L., Mycielski J., (2007), Employment fluctuations and dynamics of the aggregate average wage in Poland, 1996-2003, The Economics of Transition, The European Bank for Reconstruction and Development, vol. 15, p. 759-779

Nelson C. R., Plosser C.I., (1982), Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications, Journal of Monetary Economics, 10, p. 139-162.

Nickell S., Nunziata L., Ochel W., (2005), Unemployment in the OECD since the 1960s. What do we know?, The Economic Journal 115, p. 1-27.

Paas T., Eamets R. et al., (2006), Labor Market Flexibility, Flexicurity and Employment: Lessons of the Baltic States, Nova Science, Hauppauge NY.

Papell D. H., Murray C. J., Ghiblawi H. (2000), The structure of unemployment, The Review of Economics and Statistics, Vol. 82, pp. 309-315.

Pesaran, M.H., (2003),A Simple Panel Unit Root Test in the Presence of Cross Section Dependence, Cambridge Working Papers in Economics 0346, Faculty of Economics, University of Cambridge, Cambridge.

Ravenna F., (2007), Vector autoregressions and reduced form representations of DSGE models, Journal of Monetary Economics 54(7), p. 2048-2064

Saikkonen P., (1999), Testing normalization and overidentification of cointegrating vectors in vector autoregressive processes, Econometric Reviews 18, 235-257.

Saikkonen P., Luukkonen R., (1997), Testing cointegration in infinite order vector autoregressive processes, Journal of of Econometrics 81, 93 - 129.

Saikkonen P., Ltkepohl, H., (2000), Trend adjustment prior to testing for the cointegrating rank of a vector autoregressive processes, Journal of Time Series Analysis 21, 435 - 456.

Yang, M. (1997), On Identifying Permanent and Transitory Shocks in VAR Processes, Economic Letters 58, 171-175.