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

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**Abstract**

We analyze with panel SVECM the impact of real wage, productivity, labor demand and supply shocks on the eight CEE economies during 1996-2007. We use a set of long-run restrictions, derived from the DSGE model with explicitly modeled labor market, to identify these structural shocks. Fluctuations in foreign demand are controlled for. We find that the propagation of shocks on CEE labor markets resembles the one found for OECD countries. Labor demand shocks emerge as the main determinant of employment and unemployment variability in the short-run. The retrospective simulations of the model show that the wage adjustments were important factor behind the diverse labor market performance of the countries studied. Downward wage rigidities were especially binding after employment-contracting shocks in Poland, Czech Republic, Lithuania.

**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

Since early 1990s most Central and Eastern European countries managed to transform centrally planned economies and integrate themselves into global production chains and trade system. Particular success was shared by eight post-communist states - Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia - which joined the European Union in 2004. In this paper we focus on that group, called NMS8.

Transition shocks played a principal role for macroeconomic behavior of those countries in the early 1990s. With time, however, the relative importance of these shocks faded. In the mid 1990s business cycle in most NMS8 began to follow a coordinated pattern of upturns and slowdowns, typical for free-market economies. At the same time, average GDP growth rates and the amplitude of 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 Rep., 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 gap between the lowest, then Hungary, and the highest, then Poland, unemployment country amounted to 10 pp. In 2007, the average unemployment was down to 5 percent, and the spread between Lithuania (lowest) and Slovakia (highest) reduced to less than 5 pp.

An important question is whether these different evolutions were caused by idiosyncratic disturbances or rather by country specific, possibly institutionally driven, ability to absorb shocks on the labor market.[1] In this paper we try to address it empirically. 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. Impulse response and historical variance decomposition analyzes are performed. Then a range of thought experiments is conducted, to study the impact of certain structural shocks and wage rigidities on historical NMS8 labor market evolutions.

Applying SVECM to labor market constitutes a generalization of SVAR approach initiated by Blanchard and Quah (1989) seminal paper and developed thereafter eg. by Gamber and Joutz (1993), 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

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

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 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 external factors - fluctuations of 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, usually inferred from a multi-equation stylized labor market model (Jacobson et al., 1997, Jacobson, Vredin and Warne, 1998, Balmaseda et al., 2000), are derived from a structural Dynamic Stochastic General Equilibrium model.

The paper is organized as follows. Section one introduces the 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 to pinpoint shocks that drove NMS8 labor markets in 1996-2007 to a greatest extent. We distinguish between original shocks and wage rigidities. Final section concludes.

# 1 DSGE model of labor market

## 1.1 Introduction

To quantify and interpret the 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 the analyzed time series. The model presented in this section provides us with a catalogue of long-term relations between structural 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 et al. (1997), Balmaseda et al. (2000), however, contrary to these authors, we do not use a multi-equation stylized model, but utilize a structural DSGE framework. Establishing long-term restrictions on the basis of DSGE model - grounded on optimal behavior of the economic agents - is methodologically more attractive than the traditional *ad-hoc* approach. There is a direct correspondence between variables and shocks included in the DSGE model, and those

analyzed empirically. It provides a transparent identification of structural shocks in SVECM. 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

We consider a *textbook* RBC model of closed economy, supplemented with the labor market modeled in a Mortensen and Pissarides (1994) tradition. Variables top-indexed by $e$ and $u$ refer respectively to the employed and unemployed part of population. In time $t \geq 0$ the economy is populated by $N_t$ agents who form a representative dynasty, that in time $t = 0$ maximizes its expected lifetime utility from consumption, $c_t$ and leisure, $1 - h_t$

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

where $h_t$ denotes intensive labor supply. Instantaneous felicity function is of the CRRA class. Population is normalized to one in the steady state, i.e. $N_t = e^{\xi_t^N}$, where $\xi_t^N$ is the labor supply shock, which equals zero in the steady state. Household is confronted with the following budget constraints

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

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. Parameter $\delta_e$ denotes the exogenous rate of job destruction, whereas $\Phi_t$ is a probability of finding a job by an unemployed. Firms own capital $K_t$ and produce final good $Y_t$ with the standard Cobb-Douglas technology. They maximize the present value, $\Pi_0^A = E_0 \sum_{t=0}^{\infty} \Lambda^t \Pi_t$, of the stream of discounted profits, $\Pi_t$, where $\Lambda^t$, is a *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

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

where $\Psi_t$ denotes the probability of filling a vacancy, and $\xi_t^Y$ is a technological shock. Variable $\xi_t^V$, equal to 0 in the steady state. As it influences the recruitment costs, it can be interpreted as a labor demand shock. We fix $P_t = 1$ as *numeraire*.

As in the empirical analysis, we use variables specified in "per worker" or "per capita" terms, and hours worked are fixed. Wages are negotiated between households and firms in the Nash bargaining. Household's surplus

is denoted by $\Gamma_t = \frac{\partial E_0 \mathcal{U}_0}{\partial N_t^e}$, whereas firm's by $\Sigma_t = \frac{\partial E_0 \Pi_0^A}{\partial N_t^d}$. When maximizing the total surplus, $(\Sigma_t^V \lambda_t)^{\xi_t^W} (\Gamma_t^N)^{1-\xi_t^W}$, with shadow price of consumption $\lambda_t$ recalculating the product into utility units, both parties take into account the first order conditions implied by their optimization problems. These are calculated with respect to (i) job supply $N_t^e$ in case of households, and (ii) job demand $N_t^d$ in case of firms. 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.

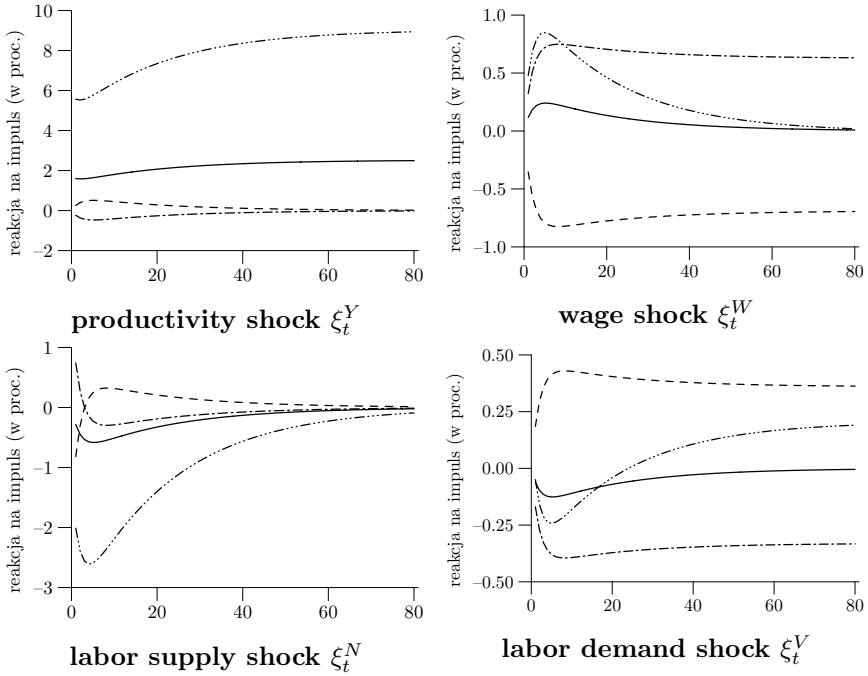
Description of the labor market is completed with matching technology $M_t = (V_t)^\theta (N_t^u)^{1-\theta}$ which relates the number of jobs filled $M_t$ to opened vacancies $V_t$, and total search effort $N_t^u \times h_t^u$. Parameter $\theta$ controls the relative importance of each factor. Variable $M_t$ defines 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 $\Phi_t = \frac{M_t}{N_t^u}$. Parameters of utility, production and matching functions are calibrated on standard levels. 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 $\sigma_X$. Moreover $\mu_Y = \mu_L = \mu_V = 0$ and $\mu_W = 0.5$, although this choice is generic, i.e. other values do not change the long-term properties of the model.

### 1.3 Long-term properties of the model

Logarithms of labor productivity, employment rate, unemployment indicator (fraction of the unemployed in the total population) 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 variable in question returns to its steady state level as the shock fades away. It is not the case if $\rho_X = 1$. Jacobson et al.(1997) and Balmaseda et al. (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. So we set $\rho_Y = \rho_L = \rho_V = \rho_W = 1$.

DSGE model responses to permanent shocks are presented on the Figure 1. It can be inferred that in the long run: (1) productivity shock increases wages and labor productivity but is neutral for employment and unemployment, (2)innovation to wage setting process permanently influences employment and unemployment but has no long-term impact on wages and productivity, (3)labor supply disturbance is neutral in the long-term for all variables, (4)labor demand shock changes the long-run levels of employment, unemployment and wages but is neutral for productivity.

**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 Empirical model

This section presents the empirical model. Starting with specification of the model and the estimation method, we move to dynamic properties of the data. Then identification issues and (reduced form) estimation results are discussed.

## 2.1 Specification

Employed panel SVECM has the following reduced form:

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

for $t = 1, 2, ..., T$, where $y_t^n$, n = 1,2,...,N, stands for a $m \times 1$ vector of n-th country's regressors, $r$ for a dimension of the cointegration space which basis vectors are stored in a $m \times r$ matrix $\beta$, and $\alpha^n$ is a $m \times r$ matrix of loading factors. $\Gamma_p$'s, $p = 1,2,\ldots,P$, are $m \times m$ matrices and $d^n$ is a $m \times 1$ vector of individual effects. We assume that $\beta$ and $\Gamma_p$'s are common across countries.

Formally, all variables in (1) are endogenous. Panel setting, however, requires controlling for common effects (Breitung and Pesaran, 2008). In order to account for these effects, we partition $y_t^n$ into $y_t^n = (y_t^{n,1}, y_t^{n,2})^T$. Vectors $y_t^{n,1}$ and $y_t^{n,2}$ represent variables called strictly endogenous and quasi-exogenous, respectively.[2] We assume that quasi-exogenous variables do not enter cointegration relations and are not influenced by strictly endogenous ones. Such an approach has several advantages. Dynamic properties of all modeled variables are accounted for within the same model. Retrospective and counterfactual experiments based on the Beveridge-Nelson representation of $y_t^n$ allow for quasi-exogenous variables, although one conducts them in a standard way. For $m = 6$, $m_1 = 4$, $r = 1$ and $P = 1$, as in our case, following exclusion restrictions are imposed:

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

$$+ \begin{pmatrix} * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ 0 & 0 & 0 & 0 & * & * \\ 0 & 0 & 0 & 0 & * & * \end{pmatrix} \Delta \begin{pmatrix} y_t^{n,1} \\ y_t^{n,2} \end{pmatrix} + \begin{pmatrix} * \\ * \\ * \\ * \\ * \\ * \end{pmatrix} + \xi_t^n$$

The reduced form model (1) is estimated with a LS-based procedure. This turns out to be advantageous in comparison with ML-based and non-parametic methods, especially for short time series (Brüggemann and Lütkepohl, 2004; Breitung, 2005). The estimation procedure consists of two steps. In the second step Breitung (2005) is followed. Unlike in Breitung (2005), however, here also the first step involves panel and GLS estimation. To calculate the Beveridge-Nelson representation of $y_t^n$, we follow Hansen (2000). In structural estimation the likelihood is maximized with the Amisano and Giannini (1997) scoring algorithm.

## 2.2 Data

Our model consists of six variables[3] - four domestic and two foreign ones:

$$y^n = [w^n, (u-n)^n, (e-n)^n, (y-p-n)^n, eu_{HP}^n, cis_{HP}^n] \tag{2}$$

The domestic block consists of four variables: average real wages, unemployment indicator, employment rate, and GDP *per* worker, which follows

[2] Their sizes are $m_1 \times 1$ and $(m - m_1) \times 1$ respectively.

[3] Balanced panel of quarterly data from 1996 to 2007 is used.

Jacobson et al. (1997), Breitung et al. (2004) and Brüggemann (2006). These variables are modeled as *stricte* endogenous. In line with Breitung and Pesaran (2008) recommendations on controlling for common effects in a panel setting, we extend the specification with a block of foreign, trade-related variables ($eu_{HP}$ and $cis_{HP}$, see Table 1). Their role is to control for global economic developments, approximated by foreign demand fluctuations. They are modeled as quasi-exogenous.

Table 1: Variables and data used

| | |
|---|---|
| $y-p-e$ | real GDP per worker, measured in Purchasing Power Standards, 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 the EU15 countries, measured as logarithm of exports in constant prices; |
| $cis_{HP}$ | business cycle (HP filtered) component of exports to the CIS, measured as logarithm of exports in constant prices. |

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

Due to different patterns of integration with the global trade among the CEE economies, and hence due to their possibly various vulnerability to external demand fluctuations,[4] foreign variables are country-specific. They are calculated as the business cycle component of a given country's exports to major trade partners in the examined period, which were the EU15 and CIS countries. For variables' definitions and data description see Table 1.

Now we turn to dynamic properties of the NMS8 time series. Breitung and Pesaran (2008) point out that traditional unit root tests have unacceptably low power in small samples. Moon and Perron (2005), however, indicate that Pesaran (2007) panel test behaves satisfactorily in small samples. Therefore we use it. 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 are not that clear-cut. Generally, tests indicate that these variables should also be modeled as I(1).[5] However, this result is not in line with empirical studies conducted for other countries.[6] We believe that the nonstationarity of employment and

[4]Illustrated by the Russian crisis in 1998, which caused economic slowdown in Baltic countries but had almost no impact on Slovenia and Hungary.

[5]This assumption was supported by standard univariate tests.

[6]Nelson and Plosser (2002) argued in favor of stationarity of US unemployment, Papell et al. (2000) and Johansen (2002) - of unemployment in several European countries,

unemployment is a small sample phenomenon.[7] Nevertheless, we proceed assuming that all domestic variables are nonstationary, whereas foreign ones are stationary.

Table 2: Critical probability values of Pesaran (2007) 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.

To estimate the cointegration rank for the system of domestic variables we apply, country be country, the Saikonnen and Lütkepohl (2000) procedure. Results 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 in first differences as an alternative. For Lithuania in turn, a two or even three dimensional cointegration space could be considered. However, as $r = 1$ is dominant, in what follows we condition the analysis on one homogenous cointegration relation being identified in the data.[8]

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).

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 economies.

[7]Time series do not reveal sufficient mean reversion in the available (short) sample.

[8]In line with eg. Jacobson et al. (1997) result for Scandinavian countries and Brüggemann (2006) for Germany.

## 2.3 Estimation results

The common interpretation of a single cointegration relation for the considered system of domestic variables[9] is that of a wage setting relation:[10]

$$\begin{array}{lccc} (w-p) = & 0.701(y-p-e) & +0.797(e-n) & +0.099(u-n) \\ & (54.19) & (7.56) & (6.79) \end{array} \tag{3}$$

One would expect that GDP *per* worker coefficient in (3) equals unity, whereas two remaining ones are zeros. Estimation results indicate that in the studied sample such a stylized relationship is violated and suggest that the evolution of GDP *per* worker in the NMS propagated into real wages less than proportionally.[11] This may reflect the fact that 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 turn out to be significant, which we believe is a small sample phenomenon. The 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, so the evolution of average wage in the aftermath of the unemployment increase can be ambiguous.[13]

## 2.4 Identification

The interpretation of shocks to domestic variables is in line with the DSGE model presented in the previous section. They are thought of as productivity, labor demand labor supply and wage setting (shifts in the relative bargaining strength of employers) shocks respectively.[14] Innovations to foreign variables are interpreted as foreign demand shocks.

Now we discuss long- and short-run identifying restrictions. One cointegration relation is accepted, so at least three out of four structural shocks can be permanent. In line with the DSGE model (see Fig. 1), we assume

[9] Foreign-demand variables are excluded.

[10] See Breitung et al. (2004) and Brüggemann (2006). Cointegration tests suggest that relation (3) is stationary.

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

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

[13] 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 the other NMS, characterized by similar institutional and structural features of the economy, paralel developments might have occurred.

[14] Such interpretation follows eg. Dolado and Jimeno (1997), Jacobson et al. (1997), Balmaseda et al. (2000), Breitung et al. (2004), Brüggemann (2006).

that: (1) productivity shocks exert only short-lived effects on employment and unemployment,[15] (2) wage setting shocks have no long-run effects on average wages,[16] but (3) may influence unemployment and employment in the long-run. Foreign variables do not enter the cointegration relation, hence we assume that (4) they do not influence wages in the long-run. Since they do not cointegrate, (5) they are assumed not to influence each other in the long-run. Finally, (6) domestic variables are restricted to not influence foreign ones in the long-run, in line with quasi-exogeneity of the latter.[17]

Identification is completed by imposing contemporaneous restrictions, which are: (1) productivity shocks influence wages with a lag of at least one quarter, (2) wage shocks do not influence employment in the same period, (3) labor supply innovations influence employment with a lag of at least one quarter, and (4) foreign demand shocks do not influence unemployment in the same period.[18]

Long-run ($EB$) and short-run ($B$) restriction matrices for $y^n = [w^n, (u-n)^n, (e-n)^n, (y-p-n)^n, eu^n_{HP}, cis^n_{HP}]$ are as follows:

$$EB = \begin{pmatrix} 0 & * & * & * & 0 & 0 \\ * & * & * & 0 & * & * \\ * & * & * & 0 & * & * \\ * & * & * & * & * & * \\ 0 & 0 & 0 & 0 & * & 0 \\ 0 & 0 & 0 & 0 & 0 & * \end{pmatrix} \quad (4) \qquad B = \begin{pmatrix} * & 0 & * & 0 & * & * \\ * & * & * & * & 0 & 0 \\ 0 & 0 & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \end{pmatrix} \quad (5)$$

## 3 Impulse responses and variance decompositions

Figures $2-6$ show the country-specific impulse responses of employment, unemployment, average wages and GDP *per* worker to structural shocks.[19] In general, the propagation of shocks on NMS labor markets echoes the one found in the literature for OECD countries. Labor demand shocks uniformly increase employment and depress unemployment in the short-

[15] Thus, we assume a Nickell rule, which states that productivity shocks do not influence employment and unemployment in the long-run, and are absorbed by output *per* worker and real wages. Such rule was empirically confirmed for a range of developed economies, see Bean and Pissarides (1993), Aghion and Howitt (1994) or Mortensen (2005).

[16] This follows from DSGE model and is in line with the cointegration relation (3), stating that average real wages are the result of an "empirical equilibrium".

[17] So foreign demand variables cannot be influenced by domestic ones at any horizon.

[18] So foreign demand shocks enter domestic labor market only *via* GDP and employment.

[19] IR functions are normalized in such a way that the initial response of a given variable to its structural disturbance (eg. employment in case of a labor demand shock) is 1%. For clarity of exposition and to save space we show only point estimates. In the text, the distinctions between significant and insignificant responses are based on bootstrap 90%confidence intervals (1000 replications) which are available upon request.

run, and, except for Czech Rep. and Lithuania, also in long-run (Fig. 2).[20] The response of average wages to a labor demand shock is moderate and pro-cyclical, except for Slovenia and Latvia, where it is slightly counter-cyclical. So in these two countries such innovations might have increased the employment of low-productivity, low-wage workers to greater extent, resulting in higher employment, but lower average wages.

A positive productivity shock temporarily depresses employment and rises unemployment, but in the long-run leads to higher output *per* worker and real wages (Fig. 5). Hence, the destruction effect of productivity surge initially dominates over the capitalization effect, but in the long term it becomes inferior (Fisher, 2006; Michelacci and Lopez-Salido, 2007).[21] We find that the spike in unemployment vanishes after 3-4 quarters in Estonia, Poland and Slovenia, but after nearly double that period in Czech Rep. and Hungary. The latter economies exhibit among the NMS also the strongest response of the unemployment to a productivity shock.

A positive wage shock reduces employment and increases unemployment in the NMS, in Lithuania and Poland even in the long-run (Fig. 4). Unemployment rises also after a labor supply shock (Fig. 3), and Poland stands out as the only analyzed economy with merely transitory increases.[22] Except for Slovakia, average wages do not response significantly to a labor supply increase, which may indicate wage rigidities in the NMS. Figures 6-7 show that the responses of NMS labor markets to the disturbances in foreign demand fluctuations are in line with the intuition - a positive export shock increases GDP *per* worker, average real wages, employment; and decreases unemployment. However, these reactions are rather small.[23]

Next, we discuss the contribution of each shock to the variability of main variables of interest, ie. average wages, employment and unemployment. The transmission of productivity shocks to average wage levels (Fig. 8) takes the longest in Czech Rep., Latvia, Slovakia and Slovenia. In these economies labor demand and supply shocks account for large part of wages' variability in the short- and medium-term. Latvia stands out with the highest contribution of wage shocks to the variance of average wages in all horizons.

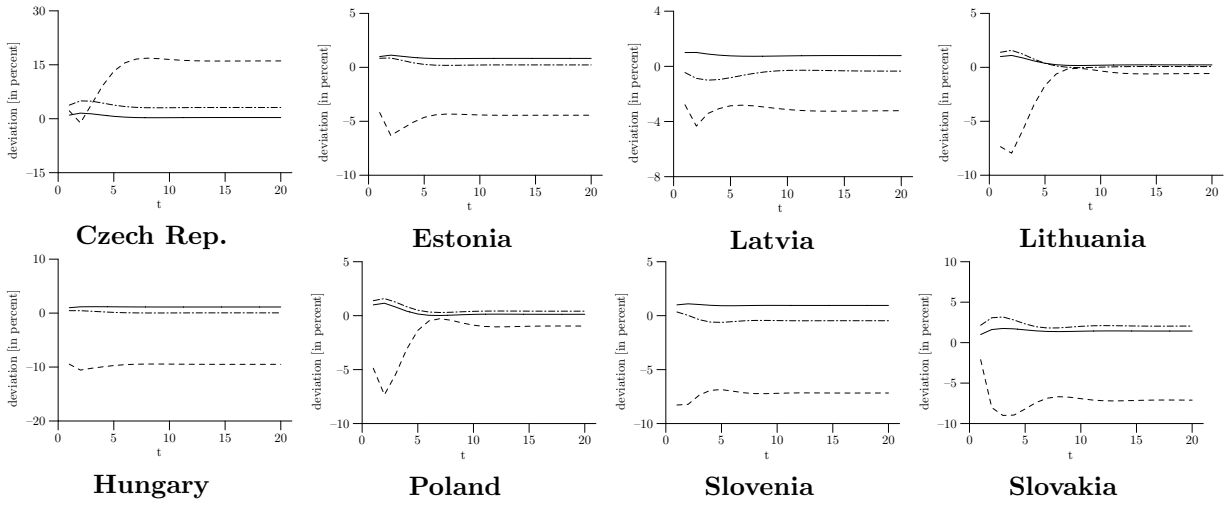
[20] The long-lasting impact of labor demand shocks was found by Breitung et al. (2004) for Canada and Brüggemann (2006) for Germany. Transitory responses in Czech Rep. and Lithuania resemble the results by Jacobson et al. (1997) for Norway and Sweden. We do not think that this mirrors any institutional features of these two NMS.

[21] Such pattern is analogous to the one revealed in SVAR/SVECM studies of US and UE15 economies (Blanchard and Quah, 1989; Balmaseda et al., 2000; Brüggemann, 2006).

[22] Some negative labor supply shocks in Poland are attributed to the welfare system influence (Fortuny, Nesporova and Popova, 2003; Bukowski and Lewandowski, 2006). Our result suggests that institutionally-driven decreases in the labor market participation led only to short-lived reductions in unemployment.

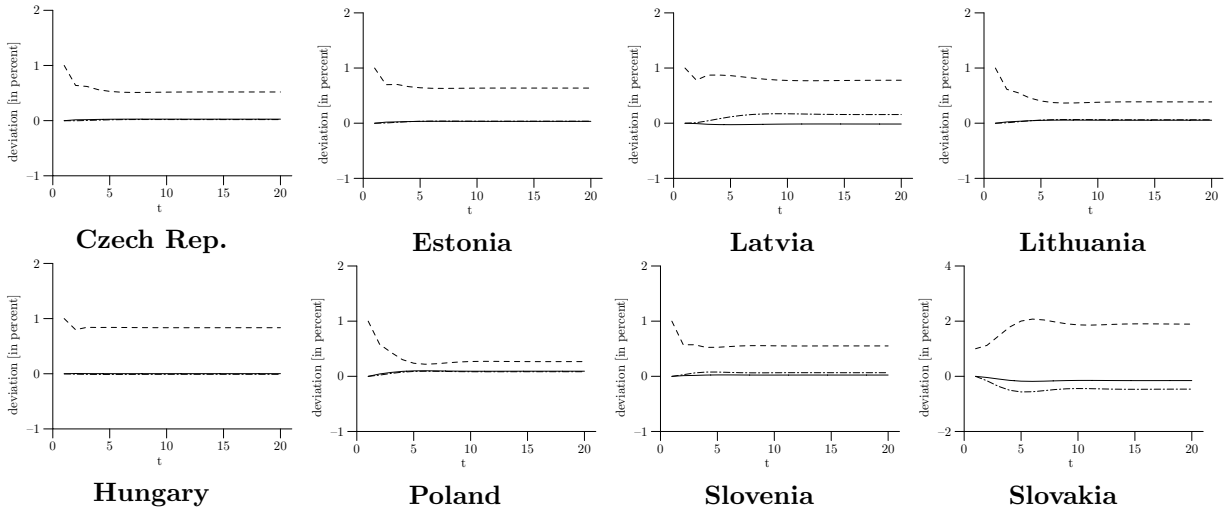
[23] Structural export shocks are constructed as the departures from business-cycle frequency movements of the variables. So they should be interpreted differently than domestic structural shocks (the departures from variables' movements in all frequencies).

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



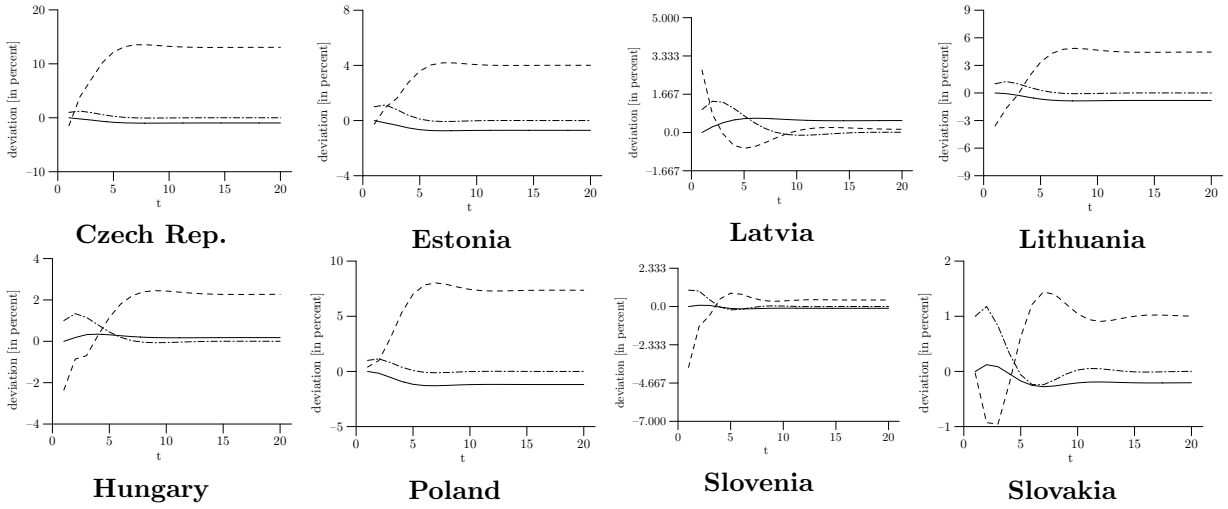

solid line – employment; dashed line – unemployment; one-dot line – average wages.

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



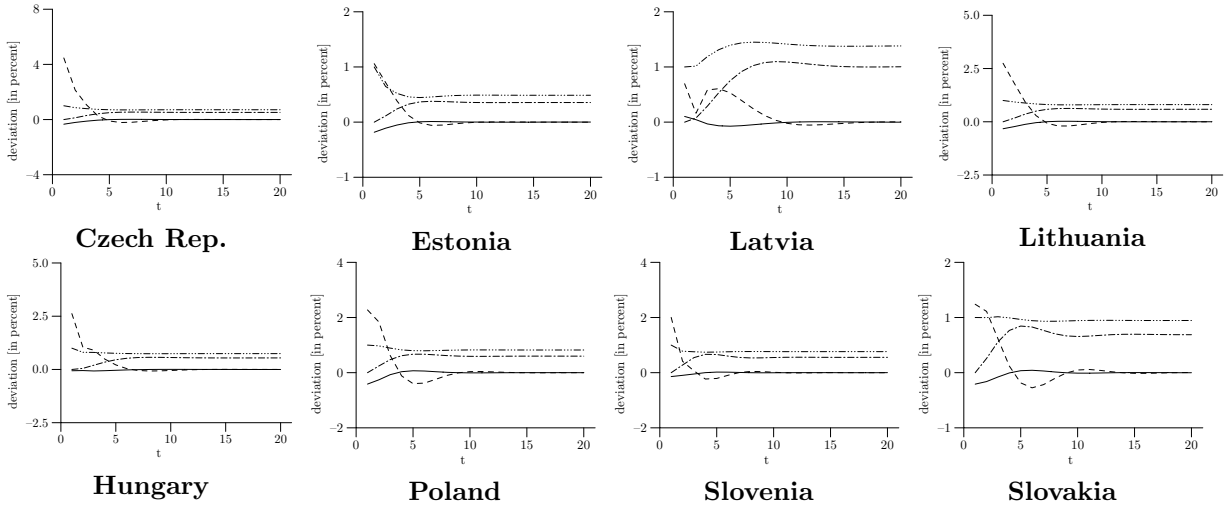

solid line – employment; dashed line – unemployment; one-dot line – average wages.

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



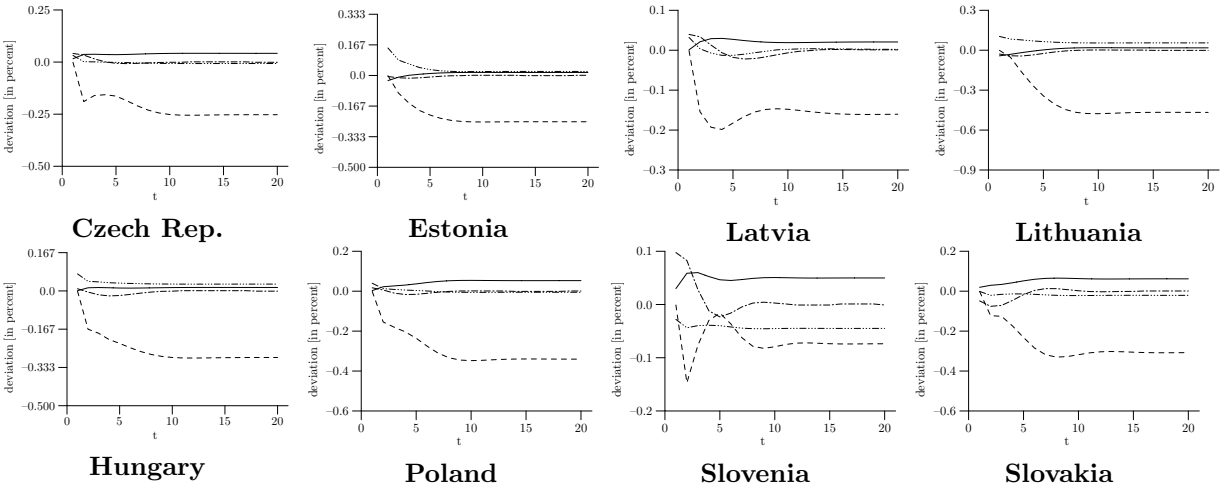

solid line – employment; dashed line – unemployment; one-dot line – average wages.

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



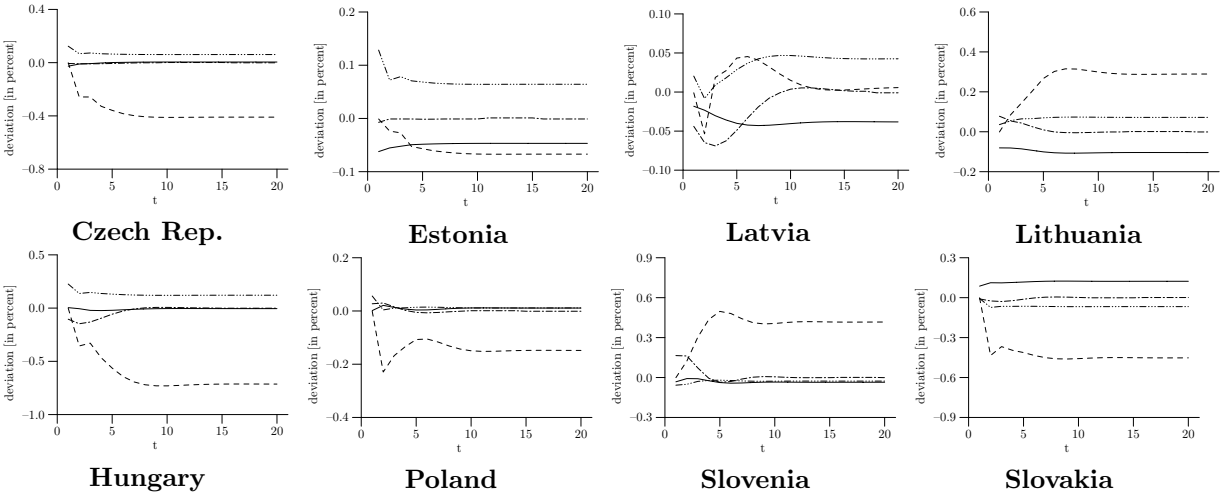

solid line – employment; dashed line – unemployment; one-dot line – average wages,
three-dots line – GDP per worker.

**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**

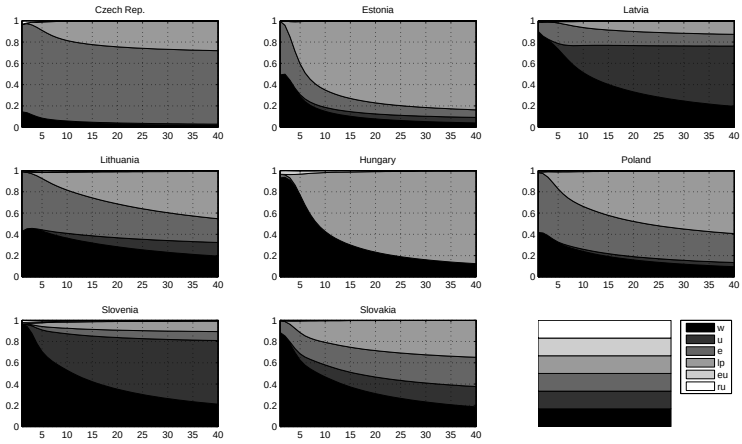



solid line – employment; dashed line – unemployment; one-dot line – average wages,
three-dots line – GDP per worker.

In Estonia and Hungary productivity shocks drive the variability of wages dominantly, explaining roughly 60% of it even in the ten-quarter horizon.[24]

As regards employment and unemployment, labor demand shocks dominate in the short-run (up to 4 quarters) in all countries. It is consistent with Balmaseda et al. (2000) results for OECD countries. As the horizon expands, the influence of these shocks stays strong in Estonia, Hungary, Slovakia and Slovenia. In the remaining countries, the contribution of wage shocks becomes prevailing. In Poland and Lithuania these shocks are dominant as soon as after 2 years. Variance decompositions reveal the importance of shocks in trade with the CIS for the Baltic states, Poland and Slovakia. Slovakia is the only country where disturbances in the EU15 exports explain a non-negligible fraction of the unemployment and employment variability. However, we think that the long-lasting contribution of foreign demand shocks should be perceived as a small sample phenomena.[25]

**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.

[24]Only in these countries transmission of productivity into wages is comparable to the one found for most OECD countries by Balmaseda et al. (2000). Ireland was the only country in that study, where labor demand and supply shocks explained the variability of wages comparably to the degree found for Czech Rep., Lithuania, and Slovenia.

[25]Correspondingly, contribution of "CIS" shocks to the employment and unemployment variability in Czech Rep. is likely due to the identification error. Czech Republic's economic ties with the CIS have been rather weak. At the time of the Russian crisis, Czech economy suffered from the idiosyncratic currency crisis, which is not controlled explicitly. Hence the spurious influence of shocks in trade with the CIS on the Czech labor market.

**Figure 9: Historical variance decomposition of employment rate**

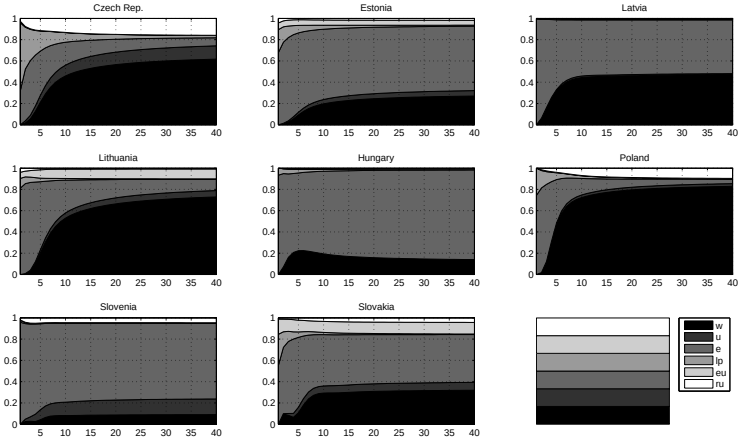
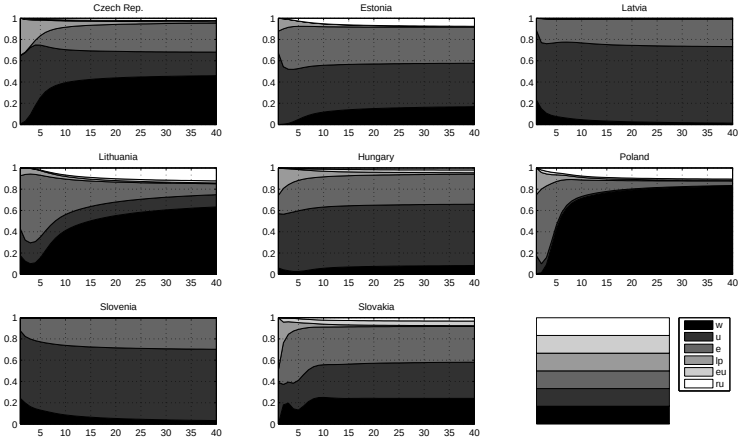



**Figure 10: Historical variance decomposition of unemployment indicator**




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

# 4 What explains the NMS labor markets' performance - retrospective SVECM simulations

In this section we try to assess which shocks were the most important determinants of the CEE labor markets' evolution in the 1996-2007 period. The estimated SVECM allows to extract from the data, for all countries in the panel, series of pairwise orthogonal structural disturbances. Estimation of the Beveridge-Nelson representation of the cointegrated stochastic process (Hansen, 2000), enables to express the evolution of each variable as a MA process contingent on these shocks. On that basis, the hypothetical evolution of analyzed economies, provided that given shock did not occur in the selected subperiod, is simulated.[26] Such thought experiments allow to pinpoint the shocks which caused swings in the unemployment in the studied sample. The focus is on demand-side shocks, ie. in fluctuations of external demand and in labor demand. The literature stressed their impact on the CEE labor markets in the analyzed period (Paas and Eamets, 2006; Bukowski and Lewandowski, 2006; OECD country studies).[27] The interactions between these "primary" shocks and innovations in wages are also analyzed. Here, a positive wage shock identified in the period of an adverse demand-side shock, is interpreted as a downward wage-rigidity, cause it indicates that wages do not react sufficiently to deteriorating market conditions.

As shown on Fig. 11,[28] the contraction of the CIS demand in 1998-1999, caused by the Russian crisis, affected labor markets of the Baltic states, Poland and Slovakia,[29] whereas Hungary and Slovenia, only marginally integrated with Russian economy, were left intact.[30] In Poland, that foreign shock caused one percentage point fall in the employment rate and a proportionate rise in the unemployment, which have propagated until the end of the analyzed period. Also Lithuania and Slovakia were affected quite strongly.[31] Estonia and Latvia seem more resilient, but Fig. 12 shows that, according to the model, in these countries the effects of exports' collapse were reinforced by the drop in labor demand. The identification of unemployment

[26] The approach is similar to the one used by Blanchard and Quah (1989). However, here SVECM is used and certain shocks are set to zero only in chosen subperiods.

[27] Strong effects of aggregate demand shocks on the OECD labor markets were identified in both SVAR setting, eg. by Blanchard and Quah (1989), Balmaseda et al. (2000), and in dynamic panel setting, eg. by Blanchard and Wolfers (2000), Nickell et al. (2005), Bassanini and Duval (2006).

[28] Shocks in both exports to the CIS and UE15 between 3q1998 and 2q1999 are set to zero. Separate simulations show that all the "joint" impact is due to the CIS shocks.

[29] 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.

[30] We do not extract business cycle movements from the data, as would be the case if exports were exogenous variables. Only structural shocks to such movements are removed.

[31] Unemployment in Slovakia increased as soon as 1997, because of the currency crisis and two-year long recession in the Czech Rep.The Russian crisis contracted further the demand for Slovakian output, which increased unemployment, as shown on Fig. 11.

drivers differs slightly among five economies where the unemployment rose in the late 90s, but generally it seems that both demand-side shocks were in force.[32] The model implies also that the labor demand in the Czech Rep. improved in the second part of 1999, and reversed the rise in unemployment.

However, the behavior of wages might have been the crucial factor behind diverse performance of the NMS labor markets at the turn of the decades. Simulations show that in Poland, Slovakia, Lithuania, and Czech Republic, wage rigidities were likely to intensify the negative impact of the Russian and Czech crisis respectively (Fig. 11). If wages adjusted flexibly to the increasing unemployment after these "primary" shocks hit, unemployment would have been significantly lower than the recorded levels. In the case of Czech Rep., the model suggests that upward wage pressures restricted the impact of positive labor demand shocks in 1999 (Fig. 12). Contrastingly, in Estonia and Latvia no contribution from inflexible wage arrangements is detected, neither when wages are interacted with the adverse external demand shocks, nor with the domestic labor demand shocks (Fig. 11-12).[33]

The divergence among the NMS labor markets continued in 2000-2002. In Hungary and Slovenia fluctuations of employment and unemployment were trivial, in comparison with the other NMS. Czech labor market stabilized. In Estonia the unemployment peaked in 2000. In Latvia and Lithuania - few quarters later, but in Lithuania, more severely affected by the Russian crisis,[34] it reached higher levels. Labor markets in Poland and Slovakia deteriorated further. The model indicates that in several NMS negative labor demand shocks occurred in 2000, and lasted for few quarters. In 2000, their direct influence was the strongest in Poland and Estonia - unemployment amounting to 2% of the working-age population is attributed to them (Fig. 13). The weak labor demand in Poland persisted in 2001, and translated into the unemployment rising till 2003 (Fig. 14).[35] In Estonia it was not the case, and the shock in 2000 merely delayed the rebound of employment.

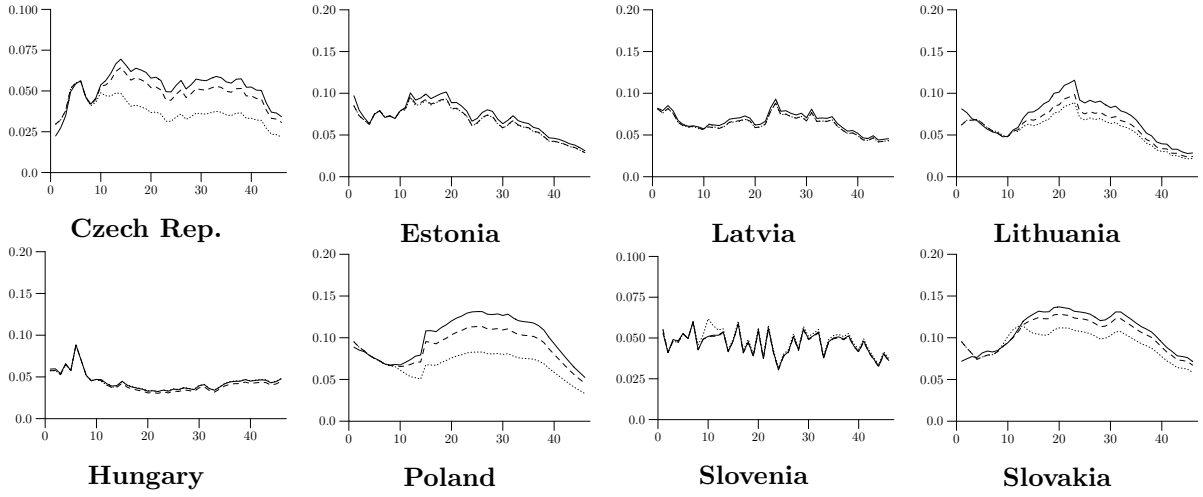
[32] According to the estimates, in Poland and Slovakia the impact of he CIS and wage shocks was so strong, that the employment should declined more than it did. Thus, the model identifies in these countries awkward positive labor demand shocks in 1999.

[33] Paas and Eamets (2006) study flexibility of wages, at national and sectoral level, in the Baltic states after the Russian crisis, and argue that Estonia and Latvia indeed had more flexible wages than Lithuania.

[34] Rutkowski (2003) notices that the contribution of firm-exits to job destruction in Lithuania increased after the ,,Russian" shock. Real GDP growth turned negative. Neither of these happened in Estonia and Latvia (Paas and Eamets, 2006).

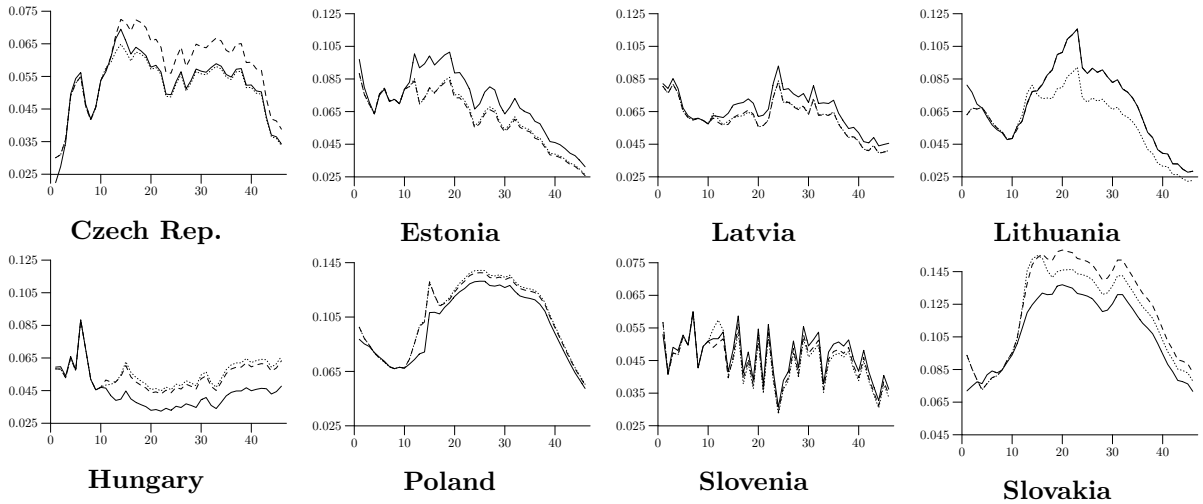
[35] Bukowski and Lewandowski (2006) argue that the aggregate capital productivity in Poland was falling from 1998 till 2003, while the investment to GDP ratio declined from 24% to 18%. In the other NMS, investment did not fall below 20% of GDP (except for Lithuania in 2000), and except for Czech Rep. and Slovakia, it has been rising from 2000 on. Barring Latvia and Slovenia, capital productivity improved in that period. The poor performance of capital, both in terms of productivity and accumulation, might explain why the labor demand in Poland was relatively lower than in the other NMS.

**Figure 11: Impact of foreign demand shocks and innovations in wages between 3q1998 and 2q1999 on unemployment in NMS (3q1996-4q2007)**



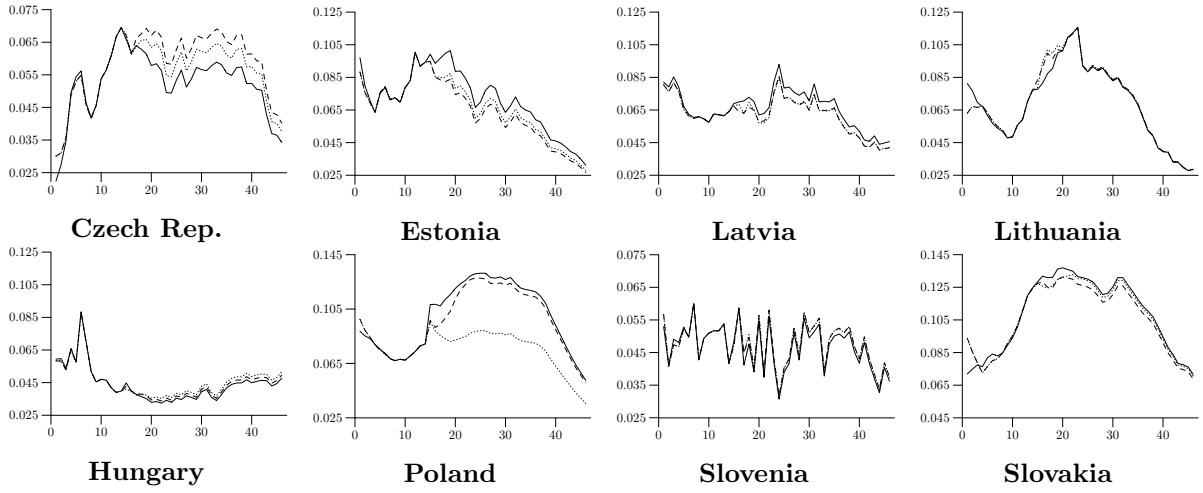

solid line – observed evolution of unemployment indicator; dashed line – hypothetical evolution of unemployment indicator provided no shocks in trade with the CIS and EU15 occurred between 3q1998and 2q1999; dotted line – hypothetical evolution of unemployment indicator provided no shocks in trade with the CIS and EU15, and no wage shocks occurred between 3q1998and 2q1999.

**Figure 12: Impact of labor demand shocks and innovations in wages between 1q1999 and 4q1999 on unemployment in NMS (3q1996-4q2007)**



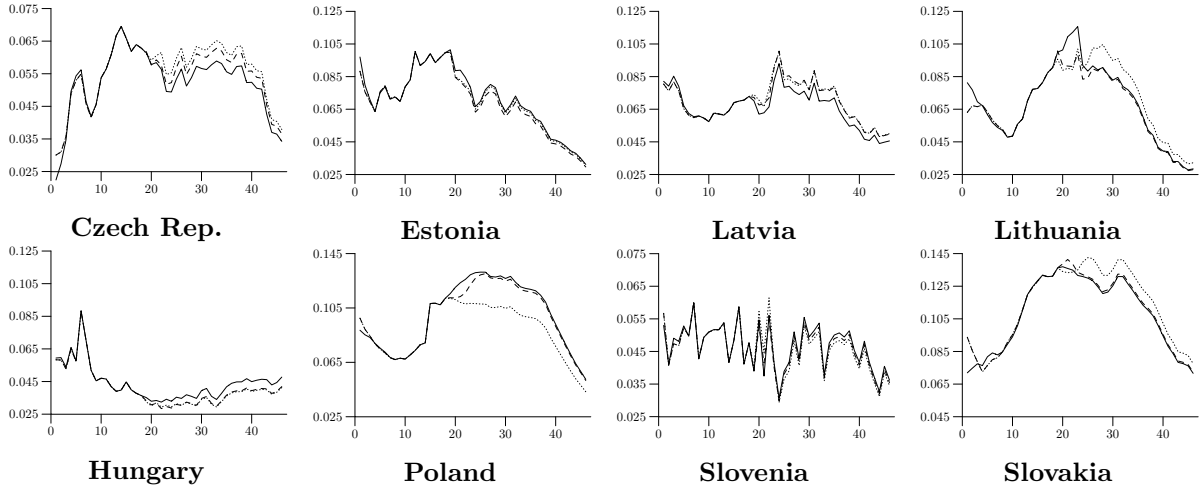

solid line – observed evolution of unemployment indicator; dashed line – hypothetical evolution of unemployment indicator provided no labor demand shocks occurred between 1q1999 and 4q1999; dotted line – hypothetical evolution of unemployment indicator provided no labor demand shocks and no wage shocks occurred between 1q1999 and 4q1999.

**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.

**Figure 14: Impact of labor demand shocks and innovations in wages between 1q2001 and 4q2001 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 1q2001 and 4q2001; dotted line – hypothetical evolution of unemployment indicator provided no labor demand shocks and no wage shocks occurred between 1q2001 and 4q2001.

However, the simulations show (Fig. 13-14) that labor demand shocks were only partly responsible for the mentioned rise of unemployment in Poland. The substantial share of it is attributed to positive wage shocks, which we interpret as downward wage rigidities in the aftermath of labor demand contraction. Short-lived, and noticeably less ample, contribution of wage rigidities is found in Latvia and Slovakia.[36] On the other hand, Estonia emerges as the country where flexible wages helped to suppress unemployment. Lithuania which, according to the model, in the late 90s suffered from the rigid wages to a greater extent than the other Baltic countries, experienced a drop in labor demand in 2001. It increased unemployment by roughly 3% of the working-age population, which as a result peaked at a higher level than in Estonia and Latvia. The model shows, however, that in 2001 wages did not intensify the "primary" impulse. In the Czech Rep., positive labor demand impulses which emerged in 1999, carried on in the following years. Interestingly, the impact of wages on unemployment turned from positive to negative in 2001. In Hungary, which maintained the low unemployment throughout the period,[37] the adverse shift in the labor demand is identified in 2001. According to the model, it increased the unemployment by approx. 1% of the working-age population from that year on.

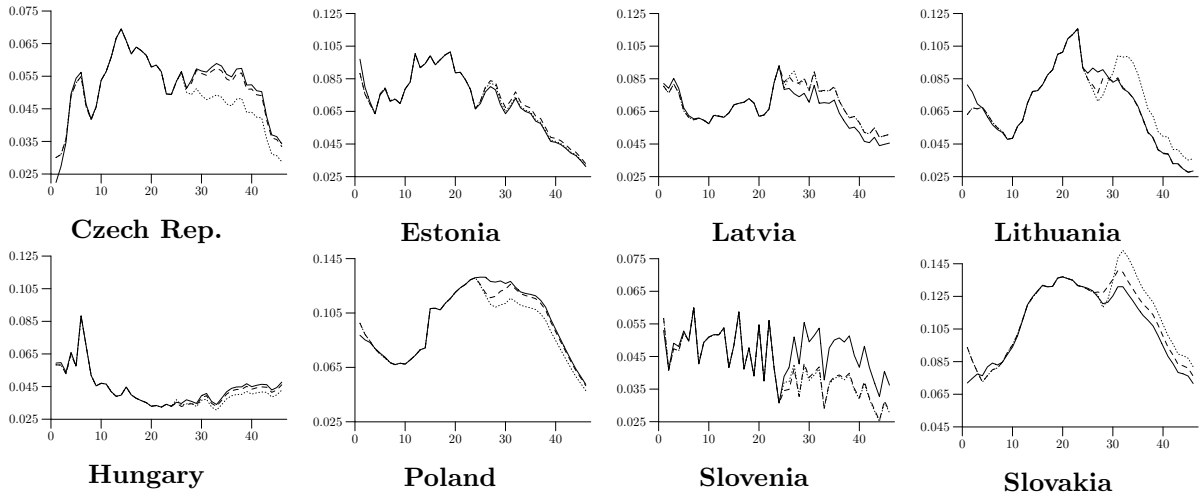
Employment losses, suffered at the turn of the decades by most of the countries studied, were reversed when the world economy recovered from the 2001-2002 slowdown. However, some differences emerge. As shown on Fig. 15, positive labor demand shocks initiated the improvement on the Slovakian and Latvian labor market in the second part of 2002, whereas in Poland and Hungary labor demand was still weak. In both Slovakia and Latvia negative wage shocks helped to reduce unemployment at the time. We think that these shocks reflect the wage inertia, ie. the low real wage growth taking place after several quarters of the deteriorating labor market. On the other hand, in the Czech Republic positive wage pressures halted the decline of unemployment - had there been no such shocks, unemployment in 2003-2005 would have been lower by roughly 1% of the working-age population.

The inertia of wages seems to have played the greatest role in Poland. Weak adjustment of wages contributed to the rising unemployment in 1998-2003, whereas the recovery on Polish labor market, initiated in 2004 by positive foreign demand shocks, was driven by negative wage shocks (Fig. 16). The average real wage growth in Poland was below GDP *per* worker growth from 2001 on (in 2004 fell to zero). This lowered the labor costs, above all in the tradables sectors and construction (Magda and Szydłowski, 2007), and enabled the aggregate employment growth. In the other NMS, the contribution of wage shocks is found to be smaller.

[36] The contribution of both labor demand and wages shocks to Slovakian unemployment seems modest in the comparison with that of 1998-1999 external demand and wage shocks.

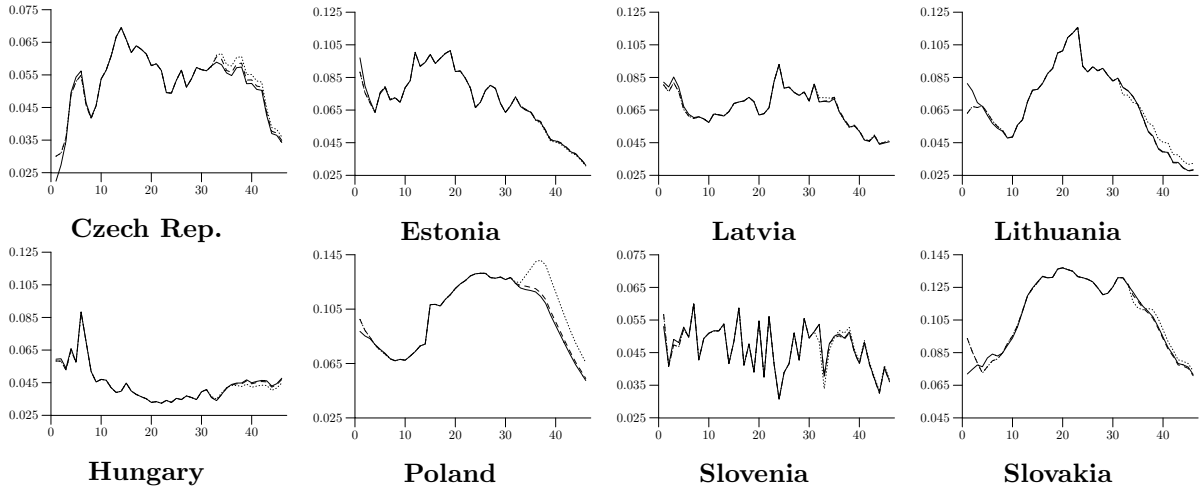
[37] But also experienced rather modest employment and low participation rates.

**Figure 15: Impact of labor demand shocks and innovations in wages between 3q2002 and 2q2003 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.

**Figure 16: Impact of foreign demand shocks and innovations in wages between 1q2004 and 4q2004 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 the CIS and EU15 occurred between 1q2004 and 4q2004; dotted line – hypothetical evolution of unemployment indicator provided no shocks in trade with the CIS and EU15, and no wage shocks occurred between 1q2004 and 4q2004.

## Conclusions

In this paper the dynamic responses of labor markets to macroeconomic shocks in the eight CEE countries are analyzed in the panel SVECM. The identification of shocks, thought of as real wage, productivity, labor demand and supply shocks, is based on the DSGE model with labor market modeled in a search-and-match block after Mortensen and Pissarides (1994). Fluctuations in the foreign demand, used as controls for the cross-section dependence, are accounted for in a *quasi-exogenous* way. The model is estimated with slightly modified Breitung (2005) panel procedure.

The main goal of the paper is to quantify the propagation of shocks on the NMS8 labor markets, and pinpoint the ones crucial for the evolution of these markets in 1996-2007. We find that impulse responses in CEE fairly resemble the mechanisms described in the literature on OECD countries. In particular, (positive) labor demand shocks increase employment, depress unemployment, and, except for Latvia and Slovenia, rise real average wages. Such shocks were found to be the main determinant of the variability of employment and unemployment in the short-run. In the medium term, demand shocks were found to be dominant in Estonia, Hungary, Slovakia and Slovenia, whereas in the Czech Republic, Latvia, Lithuania and Poland, innovations in wages seem to be prevalent. The impact of shocks in foreign demand fluctuations *per se* was moderate in most of the NMS, although the Baltic states and Poland were affected by the collapse of the CIS demand in the late 1990s. Responses to productivity shocks were found similar to the ones in OECD countries, with the destruction effect prevailing in the short-run over the capitalization effect, thus temporarily rising unemployment.

The retrospective simulations of the model suggest that the central role in evolution of CEE labor markets was played by demand-side shocks. In some countries they were accompanied by large external shocks. The most profound episode of the rising unemployment, and widening heterogeneity among the NMS, was triggered by the 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 the flexibility of wage adjustments - rigidities in the latter group intensified the detrimental impact of exports' drop. The same applies to the Czech Rep. adjustment to the 1997 currency crisis.

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

It seems that the sequence of adverse shocks explains a fair share of the differences among the CEE labor markets' evolutions in 1996-2007. Slovenia and Hungary were not affected by such severe disturbances like the Baltic states, Slovakia and Poland. However, adjustment mechanism in the form of wage flexibility influenced the performance of individual NMS - it distinguishes between Latvia and Lithuania response to the Russian crisis; and between Estonia and Poland reaction to the labor demand slump in 2000. Some countries were able to learn their lessons - wage rigidity intensified the adverse shock in Slovakia in 1998/1999, but did not as soon as in 2000.

The question is then about the institutional determinants of these rigidities. Slovenia, with its more-than-decent labor market history, has fared poorly in competitiveness rankings and has been the most unionized country among NMS. However, it may illustrate that a high degree of corporatism improves the resilience of the labor market.[38] Lithuania had much higher relative minimum wage than its neighbors when adverse shocks struck in late 90s. Since then, the Baltic republics have improved considerably, when business climate, taxation, and public spending are considered. However, they built up macroeconomic imbalances, which endanger the progress they achieved in terms of output and employment. Slovakia followed suit institutionally, but without deteriorating macroeconomic stance. Nevertheless, the relative unemployment in these countries has decreased, which may partly be because their more ,,flexible" labor market institutions - poor enforcement of employment protection legislation (EPL), weak unions, low taxation and low social security replacement rates - allow shocks to affect real and relative wages to a greater degree than in the other countries studied.[39]

Czech Republic, Hungary and Poland have had more mature product markets and less restrictive employment protection legislation than the Baltics and Slovakia, but on the other hand, have exhibited higher barriers of entry and run taxation-social security systems which discourage labor supply. The preliminary suggestion is that the high taxation and lax passive labor market policy may explain wage rigidities found in Poland. In the Czech Rep., restrictive EPL on open-ended contracts and relatively high union density with low coordination may be the reasons. However, as Boeri and Garibaldi (2006) stress, labor market institutions in the NMS are now no more rigid than in the EU15 countries. Wage bargaining schemes are more decentralized, so presumably better equipped for microeconomic wage flexibility than in the EU15. Nevertheless, the analysis of interactions between institutions in the NMS deserves more attention. Drawing on Blanchard (2007), it is worth stressing that although the future shocks are unknown, the need for flexibility of wages increases with prospects of joining the Eurozone.

[38] As argued by eg. Soskice (1990), Bassanini and Duval (2006).

[39] Bertola, Blau and Kahn (2002) argue that such feature explains partly the ,,advantage" of the US labor market over many European counterparts.

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