What if you were German? - DSGE approach to the Great Recession on labour markets

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Abstract

In this paper we utilize an open economy DSGE model to analyse factors behind the Great Recession and its transmission into labour markets of selected European countries. The labour market is modelled with the search and matching framework and accounts for labour market flows between employment and nonemployment and endogenous job destruction rate. We introduce a number of shocks which form potential sources of macroeconomic disturbances, in particular: foreign demand, productivity, bargaining power, labour demand, labour supply, government spending, and job destruction shocks. Using quarterly data for the 1996-2013 period, we estimate the model for Czech Republic, Germany, Greece, France, Spain, Poland, Sweden, and the United Kingdom, and conduct two types of experiments. First of all, we identify shocks determining macroeconomic and labour market fluctuations in each of the countries studied. We are able to distinguish between countries in which, overall during the entire period, either internal (productivity) or external (foreign demand) shocks were the main cause of economic fluctuations in GDP and its components. We also identify other specific shocks which contributed to variations in labour market outcomes and analyze the differences in their significance between countries. Secondly, we conduct simulations which allow us to compare the resilience of different economies to macroeconomic disturbances. To this end we select a reference model economy, Germany, and analyze its response to shocks identified for other countries. We find that the German economy shows the highest ability to absorb productivity and foreign demand shocks. Labour market outcomes are more varied, but differences in the relative importance of wage and employment adjustments emerge as the factor distinguishing Germany from other countries.

Keywords: Unemployment, Rigidities, Great Recession, DSGE models

JEL Classification Numbers: E32, J20, J60

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1 Introduction

The Great Recession was outstanding not only in its reach and depth but also the durability of the economic slowdown. In many countries the impact of the Great Recession on labour markets was even more severe than on economic growth. In the 4th quarter of 2009, the unemployment rate in OECD countries averaged 8.7%, the highest level in the post-war period. Despite the global economy returning to positive growth, in 2011 the unemployment rate in OECD averaged 8.3%, which meant that 44.8 million people were looking for jobs, with long-term unemployment increasing. However, the adjustments on labour markets were multidimensional and included changes in the number of employed, their hours worked or wages, and changes in labour productivity. The response of unemployment was heterogenous - while in the GIIPS countries and the United States the unemployment rate increased 2-3 times, in European countries outside the GIIPS group it grew on average by just under a fifth. In most countries unemployment peaked in 2009 and 2010 and declined thereafter, but in the GIIPS it was still growing while employment was falling in 2011-2012. Moreover, Marelli, Signorelli and Tyrowicz (2012) show that co-movement patterns of labour productivity and wages were widely different in particular EU economies, and the relative importance of quantitative (employment) and price (wages) adjustments were also diversified. The Baltic countries (Estonia, Lithuania, and Latvia) recorded one of Europe's largest increases in unemployment rate in 2008-2010, by about 15 percentage points, but in subsequent years experienced the largest drop in unemployment rate, and real labour costs in these countries had already started to decline in 2008, decreasing by 10% till 2012. In the GIIPS countries, except for Ireland, wage adjustments were modest and in Italy labour costs have continued to rise after 2008. In Greece, the first impact of the crisis was accompanied by a sharp increase in labour costs, and a significant decline from 2010 did not prevent the further rise in unemployment.

The crisis, initially limited to the U.S. market, spilled into the global economy through multiple channels of transmission - Gardó and Martin (2010) distinguish two main groups of them: financial and real; dividing the financial channels into direct, indirect and second-round effects. Among real channels, international trade was of particular importance - in 2009, global trade volume decreased by 10.5%, and it is argued (IMF, 2011) that it played a crucial role in the spread of the crisis between countries. For instance, Enders and Peter (2012) claim that as much as 70% of the change in economic conditions during the Great Recession in Germany may be explained by the impact of international trade, and ascribe the remaining 30% of the recession to the financial channel. Different channels of transmission were also partly responsible for heterogeneity of developments on labour markets (OECD, 2010), but various resilience of particular labour markets to macroeconomic shocks also played a crucial role (OECD, 2012).

An important question is to what extent these contrasting evolutions were due to idiosyncratic disturbances, and to what extent to country-specific, possibly institutionally driven, ability to absorb shocks.[1] In this paper we try to address it using a DSGE model of open economy with elaborated labour market. In our approach, we concentrate only on the real transmission mechanisms, omitting the financial ones. We apply the model to the following European countries: Czech Republic, Germany, Greece, France, Spain, Poland, Sweden, United Kingdom; which experienced different developments during the

[1] This question was studied empirically by e.g. Layard, Nickell and Jackman (1991), Bean (1994), Blanchard and Wolfers (2000), Nickell, Nunziata and Ochel (2005), Blanchard (2006), Bassanini and Duval (2006), Bukowski, Koloch and Lewandowski (2013).

Great Recession and exhibit various institutional settings. The paper is structured as follows. In section 2 we present the model, solution and estimation methodology. In section 3 the model is used to identify shocks determining macroeconomic and labour market fluctuations in each countries studied. We also conduct experiments allowing us to assess to what extent differences between countries (Germany being the reference point) with regard to macroeconomic and labour market fluctuations resulted from different shocks affecting them, and to what extent from different resilience of particular economies. Section 4 concludes.

2 Methodology

For the purpose of our analysis we construct a DSGE model. Its specification is a result of two opposing factors. On the one hand we would like a fairly simple and tractable model that contains mechanisms standard for the literature so that its results will be easily interpretable. On the other hand, to answer the question put forth in the study we require a model that incorporates a rather rich economic structure, so we are be able to fit the model with shocks corresponding to different economic channels and identify which of them were responsible for cyclical fluctuations.
The main economic elements included in the model are the following: (i) open economy, (ii) intermediate use in production structure, (iii) differentiated final goods production, (iv) government sector, (v) basic real frictions. The labour market is modelled with an augmented search and matching framework based on Mortensen (1989) and Pissarides (1990) and accounts for labour market flows between employment and nonemployment and endogenous job destruction rate. In the model we consider the following sources of fluctuations: (1) foreign demand shock, (2) technology shock, (3) wage bargaining power shock, (4) labour demand shock, (5) labour supply shock, (6) public consumption shock, (7) job destruction rate shock. While this list does not not cover all possible sources of economic disturbances that were at play during the Great Recession, we are able to explain most of the variation in the main macroeconomic variables, as discussed in section 3.

2.1 Model description

Household. We assume that the household consists of a continuum of individuals defined on the interval (0,1), who maximize expected utility $\tilde{U}_t$ from effective consumption $\tilde{C}_t$ of the form:

$$\tilde{U}_t = \frac{\tilde{C}_t^{1-\sigma} - 1}{1-\sigma} + \beta E_t\{\tilde{U}_{t+1}\}$$

Effective consumption is made from market goods C_t and home goods H_t which are produced by non-employed NE_t members of the household with efficiency set by parameter b. The efficiency parameter is interpreted as the labour supply shock.

$$\tilde{C}_t = (C_t^{\epsilon_{CH}} + H_t^{\epsilon_{CH}})^{\frac{1}{\epsilon_{CH}}}$$
$$H_t = b \times NE_t$$

We introduce heterogeneity of household members, which allows for the implementation of endogenous job destruction. Household members, indexed by $i \in (0,1)$, differ in their

individual productivity, $A_t^i = e^{a_t^i}$, which we assume evolves according to:

$$a_t^i = a_{t-1}^i + \eta_t^i$$

where $\eta^i(o) \sim N(0, \sigma_A)$ is a normally distributes random variable. Individual productivity therefore follows geometric random walk. In each period, after the realization of individual productivity shock, firms and household members can decide to terminate or continue an individual job relationship ($N_t^i \in \{0, 1\}$) based on its profitability for both sides and negotiate wage W_t^i. The motion of individual productivity results in an aggregate distribution of productivity of the employed which is approximated using Chebyshev polynomials. The exact implementation and solution method of this type of heterogeneity is explained in detail in Antosiewicz, Bukowski and Kowal (2011b).
The household income consists of wages $\int_0^1 W_t^i N_t^i di$, profits from firms Π_t and interest from bonds B_t. The expenditure side consists of consumption goods $P_t^C C_t$, lump sum taxes T_t and cost of sending job offers Ξ_t with endogenous intensity e_t. The budget constraint of the household can be written as:

$$P_t^C C_t + T_t + \Xi_t = \Delta_t^B + \Pi_t + \Pi_t^B + \int_0^1 W_t^i N_t^i di.$$

where

$$\Delta_t^B = \Big(B_{t-1}^H - \frac{B_t^H}{R_t^H}\Big) + B_{t-1}^F \frac{q_t}{q_{t-1}} - \Big(\frac{B_t^F}{R_t^F RP_t}\Big)$$
$$\Xi_t = \Big(\overline{c}_U \times (e_t - \overline{e}) + \psi_u \times (e_t - \overline{e})^2\Big) \times NE_t$$

In the above RP_t is a risk premium associated with investment in foreign bonds.

Basic goods firm. Production in the model is two-step. In the first step the representative basic firm produces basic good Y_t, using capital, labour and intermediate material. In the second phase final good producers buy the product of the basic firm, combine it with import goods to produce final goods.
The representative basic good producing firm maximizes discounted stream of profits $\tilde{\Pi}_t$:

$$\tilde{\Pi}_t = \Pi_t + E_t\{\Lambda_{t+1}\tilde{\Pi}_{t+1}\},$$

where $\Lambda_t = \beta\frac{\lambda_t}{\lambda_{t-1}}$ is the pricing kernel due to the household. The firm uses Cobb-Douglas technology to combine capital K_t and labour N_t:

$$Y_t^{NK} = K_{t-1}^{\alpha} \tilde{N}_t^{1-\alpha}$$

and a CES production function to combine the capital-labour composite good Y_t^{NK} with intermediate material Z_t:

$$Y_t = A^Y \times \Big(\theta^{\frac{1}{\epsilon_Z}} (Y_t^{NK})^{\frac{\epsilon_Z - 1}{\epsilon_Z}} + (1-\theta)^{\frac{1}{\epsilon_Z}} (Z_t)^{\frac{\epsilon_Z - 1}{\epsilon_Z}}\Big)^{\frac{\epsilon_Z}{\epsilon_Z - 1}}$$

where A^Y denotes technology level and the technology shock. The accumulation of capital is subject to investment frictions, whose extent is set by parameter ϵ_K:

$$K_t = (1 - \frac{1}{\epsilon_K}\delta) K_{t-1} + \Big(\frac{I_t}{K_{t-1}}\Big)^{\epsilon_K} K_{t-1}$$

The profit of the firm is given by:

$$\Pi_t = P_t Y_t - P_t^Z Z_t - P_t^I I_t - \int_0^1 W_t^i N_t^i di - \overline{\varpi} V_t$$

where V_t denotes vacancies posted by firms and $\overline{\varpi}$ is the cost of setting vacancies and used as the labour demand shock.

Final goods firms We distinguish the following final goods firms indexed by $f \in \mathcal{F}$: consumption, government, investment, intermediate material and export good. The production of final goods involves combining home produced basic good $Y_t^{f,H}$ and imported basic goods $Y_t^{f,F}$ using CES production function:

$$Y_t = \left((\theta_H^f)^{\frac{1}{\epsilon_f}} (Y_t^{f,H})^{\frac{\epsilon_f - 1}{\epsilon_f}} + (1 - \theta_H^f)^{\frac{1}{\epsilon_f}} (Y_t^{f,F})^{\frac{\epsilon_f - 1}{\epsilon_f}} \right)^{\frac{\epsilon_f}{\epsilon_f - 1}}$$

where parameter θ_H^f sets the share of home produced goods. Note that for the export final firm this parameter is equal to 1. Final goods firms maximize one-period profits:

$$\Pi_t^f = P_t^f Y_t^f - P_t Y_t^{f,H} - P_t^F \times q_t \times Y_t^{f,F}$$

where q_t is the real foreign exchange rate.

Open economy. The open economy is modeled in a simplified way. Final goods firms are responsible for both imports and exports. We assume that the volume of exports depends on foreign demand Y^F, which is used as the foreign demand shock and on relative terms of trade. Imports IM_t and exports EX_t are define as:

$$IM_t = \sum_f IM_t^f \qquad IM_t^f = P_t^F \times q_t \times Y_t^{f,F}$$

$$EX_t = P_t \times EX_t^V \qquad EX_t^V = \left(\frac{P_t}{P_t^F q_t} \right)^{-\epsilon_F} \times Y^F$$

where parameter ϵ_F sets the elasticity of exports with respect to terms of trade. The current account and capital account are given by:

$$CA_t = EX_t - IM_t$$

$$KA_t = B_{t-1}^F \frac{q_t}{q_{t-1}} - \frac{B_t^F}{R_t^F RP_t}$$

$$0 = CA_t + KA_t$$

with the last equation implicitly defining the real exchange rate.

Government. We assume that the government follows a simple fiscal rule under which it adjusts the amount of spending to deviations of GDP from its steady state. Spending is financed by lump-sum taxes T_t. This assumption implies that government debt is equal to zero, however due to the Ricardian equivalence holding in RBC models, it does not affect the results. This is summarized in the following two equations:

$$P_t^G G_t = \overline{G} \times \left(\frac{GDP_t}{GDP} \right)^{\epsilon_{GV}} \qquad T_t = P_t^G G_t$$

where $\overline{G}$ sets the steady state level of government spending and is used as the government spending shock. Moreover, we assume that a rise in government spending resulting from a government spending shock is used as a subsidy for firm investment and household consumption, and not on the public good.

Labour market. We assume a non-walrasian labour market characterized by endogenous destruction and search and matching mechanism. In each period the number of employed evolves according to:

$$N_t = (1-\overline{\rho})(1-s_t) \times \Big(N_{t-1} + M_{t-1}\Big) \tag{1}$$

where $\overline{\rho}$ and s_t denote the exogenous and endogenous destruction rates respectively. The number of new job matches M_t depends on the number of posted vacancies V_t and job offers $\widetilde{O}_t$ sent by nonemployed job seekers NE_t.

$$M_t = \overline{\Upsilon}\widetilde{O}_t^{\psi} V_t^{1-\psi}, \tag{2}$$

Using this we can calculate the probability of finding a job and filling a vacancy as:

$$\Psi_t = \frac{M_t}{\widetilde{O}_t}, \qquad\qquad \Phi_t = \frac{M_t}{V_t}. \tag{3}$$

We assume that job seekers send job offers with intensity e_t[2], giving the total number of sent job offers as:

$$\widetilde{O}_t = \frac{1-e^{-e_t\Psi_t}}{\Psi_t} NE_t. \tag{4}$$

Wages are negotiated individually between a worker and the firm basing on the worker's individual productivity via Nash wage bargaining. Since wages depend only on the individual productivity a, we can write a general wage function of the form:

$$W_t(a) = \arg\max_{W_t(a)} \left(V_t^E(a) - V_t^U(a)\right)^{\nu} \times \left(V_t^F(a)\right)^{1-\nu}$$

where $V_t^E(a)$, $V_t^U(a)$ and $V_t^F(a)$ denote the value of employment for the worker, unemployment and value of employment for the firm of a worker with productivity equal to a. Parameter ν denotes the workers bargaining power and is also used as the wage bargaining shock. We assume that firms will endogenously sever a job relationship if its value is below a certain threshold $\tilde{c}$:

$$V_t^F(a) \leq \tilde{c}$$

Using the value of $\bar{a}_t$ for which $V_t^F(\bar{a}_t) = \tilde{c}$ we can calculate the rate of endogenous job destruction. The parameter $\tilde{c}$ is also used as the job destruction rate shock. Labour market flows are calculated using the endogenous job destruction rate and number of new job matches in each period.

Shocks. The shocks described throughout the model description, written in general by χ_t^X, where X denotes relevant parameter X affects the parameters in a multiplicative way:

$$log(X_t) = log(\overline{X}) + \chi_t^X \tag{5}$$

where $\overline{X}$ is the steady state value of given parameter. All the shocks are assumed to be first order autoregressive processes:

$$\chi_t^X = \rho^X \chi_{t-1}^X + \varepsilon_t^X \tag{6}$$

where ε_t^X is a normally distributed random variable with mean 0 and standard deviation σ_X. Altogether we consider the following sources of macroeconomic disturbances:

[2]We assume that sending job offers by individual household members follows a Poisson process.

- foreign demand shock - Y^F,
- technology shock - A^Y,
- wage bargaining power shock - ν,
- labour demand shock - $\overline{\varpi}$.
- labour supply shock - b,
- public consumption shock $\overline{G}$,
- job destruction rate shock -$\tilde{c}$,

2.2 Model estimation and parametrization

Using the model specification described in previous subsections we parameterize models for selected countries. The only difference between the country-specific models arises from different values of parameters, which are determined on the basis of the 1996-2013 quarterly data for: (1) GDP, (2) private consumption, (3) investment, (4) public consumption, (5) employment rate, (6) unemployment rate, (7) exports, (8) imports, (9) interest rate, (10) inflation, (11) foreign GDP,[3] (12) vacancy rate, (15) employment to unemployment flows, (16) unemployment to employment flows, (17) real exchange rate. Eurostat data is used and labour market flows are estimated with a methodology proposed by Elsby et al. (2008) which builds on Shimer (2007) but allows precise estimation of flow probabilities also outside of the flow steady state. HP filter is applied to obtain cyclical components. The first step of the parametrization procedure is to set the parameters responsible for the steady state properties of the model, such as employment rate, shares of GDP components, etc. These values are set in a straightforward manner. The second part consists of setting parameters responsible for the dynamic properties of the model. This group consists of parameters describing the shock processes and elasticities of production functions. These values are set in a bayesian estimation procedure, whose aim is to match the statistical moments of the model to the moments calculated from the HP-filtered cyclical component of the data. If we denote the parameters of the model as Γ, then the estimator of the parameters $\hat{\Gamma}$ can be formally written as:

$$\hat{\Gamma} = \arg\max_{\Gamma} L(\Gamma) \qquad L(\Gamma) = \sum_i \log \mathrm{pdf}^{P_i}(\Gamma_i) + \sum_j \log \mathrm{pdf}^{M_j}(M_j(\Gamma))$$

where pdf^{P_i} is the *a priori* distribution of the i-th parameter of the model and pdf^{M_j} is the distribution of moment M_j. The *a priori* distributions of most parameters are set in line with the literature. In case of parameters controlling public consumption and foreign demand their *a priori* distributions were set using results of estimation for relevant equations on data. Regarding statistical moments, we assume that pdf^{M_j} is formally distributed with mean equal to the particular moment calculated from the data and empirical standard deviation of GDP. For remaining variables, we report standard deviation relative to the deviation of GDP. The country specific models imply significantly higher volatility of GDP than in the data for all countries. This however is not a serious

Table 1 shows the moments of the selected variables (cyclical component) calculated from relevant time series and implied by the model. The first row shows the implied

[3]Calculated for each country as an average GDP (in PPP) of its foreign trade partners, weighted by the structure of exports of a particular country.

Table 1: Standard deviation of cyclical component of GDP and relative-to-GDP standard deviation of cyclical component of selected macroeconomic variables - model and data (in %)

variable	type	CZ	DE	ES	FR	GR	PL	SE	UK
GDP	data	1.73	1.29	1.13	0.91	1.53	1.23	1.79	1.13
	model	4.31	3.00	3.95	3.01	2.79	3.62	3.12	3.12
Private consumption	data	0.69	0.60	0.86	0.60	1.06	0.77	0.58	0.67
	model	0.75	0.72	0.77	0.77	0.77	0.73	0.77	0.7
Investment	data	3.48	3.66	3.76	4.59	4.73	5.16	3.84	4.35
	model	2.62	3.54	2.18	3.29	3.14	3.22	3.49	3.68
Wages	data	0.80	0.72	0.91	0.76	1.79	1.72	0.71	0.72
	model	0.83	0.80	0.81	0.80	0.79	0.76	0.86	0.82
Employment rate	data	0.60	0.63	0.99	0.63	0.90	0.95	0.67	0.57
	model	0.22	0.19	0.27	0.21	0.21	0.29	0.20	0.21
Unemployment rate	data	6.79	5.29	7.88	6.17	6.05	7.76	5.90	5.4
	model	1.69	1.25	1.18	1.42	1.09	1.08	1.42	1.53
Source: own calculations based on the DSGE model and Eurostat data									

drawback since results are shown with respect to all the shocks present in the model, instead of just the productivity shock, as is the case for most academic papers. What is more, the variance of shocks can always be rescaled to perfectly match the deviation of GDP. In comparison to other search and matching models such as Andolfatto (1996), Merz (1995) or Cheron and Langot (2004), our models are able to replicate quite well the relative volatility of GDP components, especially private consumption. The implied volatility of investment is slightly lower than in the data. Regarding labour market variables, the models do a very good job of replicating the volatility of wages, especially in comparison to standard RBC search models, which show values closer to 0.3-0.4, rather than 0.8.

3 Results

3.1 Historical decompositions

In this section we use the estimated models to perform two types of simulation experiments. The first one consists of historical decompositions (or model predictions) of main macroeconomic variables, conducted with respect to the shocks enumerated in subsection 2.1 with the use of the Kalman filter. Having calculated the decomposition with respect to all shocks, we can also make a prediction of model variables conditional on a single shock or a subset of shocks. Such analysis shows which shocks contributed most to cyclical fluctuations of particular variables in different economies. We calculate the following synthetic measures of the extent to which the model can fit the data:

$$\kappa_j^i = \frac{cov[HD_j^i, z_j]}{var(z_j)} \qquad \kappa_j = \sum_i \kappa_j^i$$

where HD_j^i is the time series of the historical decomposition of the (HP-filtered) cyclical component for j-th variable with respect to i-th shock, and z_j is the empirical time series

of the cyclical component of j-th variable. The sum of the partial measures, denoted by κ_j, measures the fit of the model to the data. If $\kappa_j = 1$, the model is able to fully replicate the evolution of variable j, in case of $\kappa_j > 1$ or $\kappa_j < 1$, the model predicts higher or lower volatility of a particular variable than is observed in the data.

Table 3: Summary of model historical decomposition fit to the data for countries studied, by type of shock (in %)

shocks	foreign demand	productivity	bargaining power	labour demand	labour supply	government spending	job destruction	all
GDP								
Czech Republic	60	48	1	-1	0	-5	0	98
Germany	52	30	1	0	1	-3	3	85
Spain	33	62	4	5	5	-7	8	113
France	75	53	3	-3	-3	-9	1	112
Greece	24	42	6	2	5	12	13	107
Poland	47	39	5	2	3	5	9	108
Sweden	41	32	1	-3	1	2	3	76
United Kingdom	60	28	2	0	0	1	2	92
Private consumption								
Czech Republic	8	41	2	0	1	2	2	62
Germany	31	7	-3	2	14	-4	29	80
Spain	17	15	1	5	9	-6	14	67
France	24	86	-2	-4	-2	-5	2	93
Greece	11	35	0	1	13	-7	19	72
Poland	26	-1	4	7	22	-9	37	87
Sweden	43	73	-9	-6	10	-8	10	108
United Kingdom	41	43	-2	0	4	-4	10	93
Investment								
Czech Republic	35	68	2	0	0	-1	3	106
Germany	34	92	4	0	0	-7	3	125
Spain	15	73	2	2	1	1	4	97
France	38	87	3	-1	-1	-30	4	98
Greece	12	28	2	1	0	25	7	75
Poland	21	74	2	0	1	13	5	114
Sweden	29	68	2	-1	2	11	4	114
United Kingdom	29	81	1	0	0	-8	2	106
Wages								
Czech Republic	19	67	10	-2	0	4	-6	90
Germany	-26	24	107	1	-2	-1	-11	92
Spain	-11	2	17	0	0	2	-4	6
France	-1	-1	86	3	2	-12	11	89
Greece	-5	6	12	1	0	0	3	19
Poland	6	2	2	2	0	0	4	18
Sweden	-16	89	69	-15	6	-7	-24	96
United Kingdom	18	39	33	3	1	-2	0	91
Employment rate								
Czech Republic	31	21	3	5	4	-5	41	102
Germany	17	21	6	4	6	-2	38	98

Continued on next page

Table 3 – *Continued from previous page*

	for. dem.	product.	barg. pow.	labour dem.	labour sup.	gov. spend.	job destr.	all
Spain	5	37	4	4	4	-2	9	66
France	21	19	5	8	-3	-5	43	97
Greece	0	9	7	5	8	9	24	69
Poland	15	16	12	8	10	6	35	105
Sweden	14	16	6	4	10	2	32	85
United Kingdom	30	18	9	6	5	0	21	92
Unemployment rate								
Czech Republic	18	10	2	2	2	-3	21	53
Germany	13	13	5	5	6	0	40	93
Spain	2	23	2	2	2	-2	5	38
France	18	15	4	2	-4	-2	27	62
Greece	8	3	11	4	7	9	27	75
Poland	11	5	5	4	5	2	18	52
Sweden	11	10	6	6	9	0	30	73
United Kingdom	19	12	4	3	3	2	15	60
Hazard rate of outflow from employment								
Czech Republic	13	3	-9	-5	1	1	53	50
Germany	13	18	-26	-16	2	1	126	86
Spain	3	37	-6	9	1	-2	22	68
France	16	25	-25	6	-3	-10	72	84
Greece	7	25	-35	-8	3	12	108	97
Poland	11	28	-33	12	5	2	57	90
Sweden	5	3	-13	4	2	1	82	85
United Kingdom	3	11	2	18	2	1	35	83
Hazard rate of inflow to employment								
Czech Republic	10	9	21	12	1	0	-17	50
Germany	7	6	18	23	1	1	-29	69
Spain	3	9	21	22	1	0	-24	38
France	8	0	15	34	-1	-1	-46	50
Greece	1	4	32	16	2	2	-29	55
Poland	8	-1	44	54	3	2	-82	63
Sweden	4	-3	35	57	3	2	-49	70
United Kingdom	8	3	25	39	1	1	-10	87

Source: own calculations based on the DSGE model.

The synthetic measures of the model's fit to the selected macroeconomic time series, calculated for the entire period in question, are presented in Table 1. On Figures 1 to 5 we show the predicted trajectories of variables with respect to selected shocks versus the data which allows us to identify which shocks and transmission channels contributed most in different subperiods, in particular during the Great Recession.[4] We are mainly interested in assessing the impact of the productivity shock and other shocks which can be easily interpreted in terms of structural, institutional or policy changes in the economy, or show the impact of the foreign trade channel.

[4]Due to space restrictions we limit an in-depth analysis of historical decompositions to GDP, employment, unemployment and wages, although the values of κ are shown for a larger set of variables and additional figures are available upon request.

Using all shocks, we are able to explain from 76% to 113% of GDP variation in the countries studied.[5] The model identifies two main determinants of GDP fluctuations, namely the productivity shock and the foreign demand shock. This is partly in line with the results found by Smets and Wouters (2005), who identified productivity and labour supply shocks as the main determinant of variability of GDP. It is also worth mentioning, that the model used by those authors did not take into account foreign demand shocks. We find that during the Great Recession the negative productivity shock contributed dominantly to the GDP decline in Spain, whereas foreign demand shock explained most of a slowdown in the Czech Republic, France, Germany, Poland. In Greece, the first stage of the recession was triggered by foreign demand, the second by productivity shock. Moreover, from the fourth quarter of 2011, the deviation of the cyclical component of GDP below the trend in Czech Republic, France, Germany and Poland was associated with a negative domestic productivity shock. In Sweden and the United Kingdom the impact of both shocks was of comparable magnitude. For most countries, the strength of the foreign demand shock impact was unprecedented in the period studied (both in terms of the positive contribution just before the crisis and negative during the crisis). Similarly to total GDP, fluctuations of GDP components - private consumption and investment - were also mainly driven by productivity and foreign demand shocks, however some differences emerge. Firstly, the foreign demand shocks exerted a significantly smaller impact than productivity shocks. Secondly, in all analyzed countries except of the Czech Republic, job destruction shocks were an important factor influencing private consumption. This result can be interpreted in terms of reducing or postponing consumption, presumably of durable goods, in the face of higher job loss probability. For many countries that shock proved to be more important during the Great Recession than in previous spells of economic slowdown.

During the Great Recession, many countries decided to implement government plans aimed at mitigating the effects of the Great Recession, a prime example of which are German subsidies for purchases of new cars. We implement this mechanism by assuming that excess (resulting from the government spending shock) government expenditure is used as a subsidy for firms and households to buy consumption and investment goods respectively (see Section 2). Figure 2 shows the results of modelled impact of public spending shocks on GDP. Overall, we find that during the Great Recession the contribution of fiscal shocks to GDP was countercyclical in the Czech Republic, Germany, France and Spain, and procyclical in Greece and Poland. However, we find that loose fiscal policy in Poland mitigated the economic slowdown after the Great Recession hit and contributed to an increase of GDP, although from 2012 fiscal tightening was suppressing GDP. Such evolution was even more pronounced in Greece and Spain - the negative contribution of government spending to changes in GDP in 2012 was the strongest among the analysed countries. In Sweden and the United Kingdom the fiscal shocks' impact is found to be negligible.[6] However, it should be noted that the impact of the government spending shock in all countries was small compared with the productivity and foreign demand shocks, which suggests a relatively minor significance of changes in fiscal policy for cyclical fluctuations in GDP. The model also shows (see Table 3) that government fiscal policy had a diversified impact on GDP components: on private consumption it was negative in 7 out

[5] The fit over 100% means that the model implies larger variance of HP cyclical component of a variable than observed in the data.

[6] We do not show results for public consumption as this variable is replicated by government spending shock.

of 8 analyzed countries, and on investment - negative in 4 of analyzed countries.
The fit of our model's prediction of the main labour market variables is also quite high. We find that in contrast to GDP and its components, productivity and foreign demand shocks were not the main determinants of the evolution of labour market indicators. The employment and unemployment rates were mainly determined by the job destruction shocks which explains from one third to almost half of the employment volatility in the Czech Republic, Germany, France, Poland and Sweden. Noticeable, but smaller impact was exerted by foreign demand shocks. We find that the volatility of employment in European countries was affected mainly by labour demand side factors, with supply side factors playing a much smaller role.
We find that in the Czech Republic, France, Poland, the United Kingdom the rise in unemployment during the Great Recession resulted from an overlap of the foreign demand and job destruction shocks. The negative job destruction shock was avoided by Germany and Greece - actually alleviation of job destruction mitigated the changes in unemployment in these countries in the first stage of the Great Recession, suggesting perhaps labour hoarding. In 2011-2012, the impact of foreign demand shock receded and some countries (Sweden, France and the United Kingdom) experienced a recovery in foreign demand, and this shock even began to decrease unemployment. The impact of the job destruction shock in the second stage of the crisis was more diverse. In Sweden and the United Kingdom it contributed to a decrease in unemployment, yet in France and Greece unemployment began to increase significantly due to such shock. In a very similar way, but with an opposite sign, both shocks influenced employment rates in the countries studied.
In the case of (average real) wages, the main driver of the cyclical fluctuations in most countries turned out to be the changing bargaining power of workers. The role of this factor was strongest in Germany, but it cannot simply be defined as wage pressure, as this factor was conducive to a reduction in workers' compensation below its trend in the periods when other shocks were pushing wages above the trend. Therefore, we can say that these shocks were dampening wage pressures. A similar effect was also observed in Sweden. In contrast, in the Czech Republic wage bargaining shocks were not strong enough to offset the pressure on wages resulting from large fluctuations in foreign demand, in particular those above the trend. In Poland, there was a certain inertia in the impact of wage bargaining - after several years of no wage pressure it occurred in 2009-2011, yet as soon as in 2012 the impact of shifts in bargaining power was negligible.
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Figure 1: Historical decomposition of the cyclical component of GDP with respect to productivity and foreign demand shock (in %).

blue line - productivity shock, red line - foreign demand shock, green line - empirical data

Figure 2: Historical decomposition of the cyclical component of GDP with respect to government spending shock (in %).

blue line - government spending shock shock, green line - empirical data

Figure 3: Historical decomposition of the cyclical component of unemployment rate with respect to job destruction and foreign demand shock (in %).

blue line - job destruction shock, red line - foreign demand shock, green line - empirical data

Figure 4: Historical decomposition of the cyclical component of employment rate with respect to job destruction and foreign demand shock (in %).

blue line - job destruction shock, red line - foreign demand shock, green line - empirical data

Figure 5: Historical decomposition of the cyclical component of wage with respect to bargaining power and foreign demand shock (in %).

blue line - bargaining power shock, red line - foreign demand shock, green line - empirical data

Fluctuations of inflows to employment were influenced by the greatest number of factors (see Table 3). The largest parts of the variation (on the average 32%) are explained by labour demand shocks, whereas the matching efficiency shock and bargaining power shock played a visible, but smaller role. Foreign demand also slightly contributed to variation of inflows, whereas job destruction shocks had a countercyclical effect In contrast, outflows from employment (layoffs) were determined primarily by variations in the propensity of companies to fire workers (job destruction shocks), which is associated with their predictions about the future development of the economic situation. An important contribution, though several times smaller, is also found for disturbances in foreign demand and productivity shock.

3.2 Counterfactual simulations

Having identified the shocks driving macroeconomic and labour market fluctuations in selected European countries, in this subsection we try to assess to what extent the behaviour of a given economy, relative to other economies, resulted from country-specific shocks which affected it (nature and strength of shocks), and to what extent from differences in the ability to absorb them. We assume that the latter are captured in the country-specific (estimated) parameters of the model. We perform simulations comparing the responses of analysed economies with the hypothetical response of the German economy to the same trajectory of shocks. Germany is chosen as the reference country because it is the largest EU economy and its labour market was especially resistant to the Great Recession.[7] The simulations rely on applying shocks estimated for a given country to a model parameterised for the German economy. As a result we obtain a hypothetical path that an economy would have taken, if it reacted to the shocks as the German economy would have reacted. This can be formally written in the following way. Let us denote the predicted trajectory of variable j for country b, $y^b_{j,t}$ under shocks $z^{b,X_t}, X \in \mathcal{X}$, where $\mathcal{X}$ is the set of all shocks as:

$$\{y^b_{j,t}\}_{t\in T} = F\left(p_b, \{z^{b,X_t}\}_{t\in T}\right)$$

where p_b denotes parameters estimated for model for country b, and $F()$ represents the entire model. Then, the hypothetical reaction of variable j for country b, to shocks calculated for country c can be written as:

$$\{y^{b,c}_{j,t}\}_{t\in T} = F\left(p_b, \{z^{c,X_t}\}_{t\in T}\right)$$

On each of the figures in this subsection we show three plots: model prediction of the relevant variable for a given country, $\{y^b_{j,t}\}_{t\in T}$), reference (German) model prediction of the relevant variable conditional on a history of shocks identified in a given country $\{y^{b,c}_{j,t}\}_{t\in T}$, and the HP-filtered empirical cyclical component of the relevant variable. Comparing the scale of deviation of the cyclical component for thus simulated variables to the original decomposition (i.e. showing how a given economy reacted to the identified shocks), we are able to determine to what extent fluctuations in the country resulted from the country-specific disturbances, and to what extent from country-specific reaction to them.[8]

[7] This choice is further supported by the fact that over the past two decades the cyclical fluctuations of the main labour market variables in Germany have been lower than those in other EU countries.

[8] In order to save space we show simulations of GDP, wages, employment, unemployment and labour market flows for each country. Results for other variables are available upon request.

These simulations show that the German economy exhibited the highest stability among the analysed countries. If the Czech Republic, Greece, Spain and Poland reacted to the shocks affecting them as the German economy would have reacted, they would have experienced a significantly smaller amplitude of GDP fluctuations, whereas in case of France, Sweden and United Kingdom the difference would be much lower (see Table 4). However, all of the countries studied, except for the UK, would experience smaller fluctuations of employment rate, and all except Poland would experience smaller fluctuations of unemployment rate. Importantly, all analysed economies would exhibit larger volatility of real wages had they reacted to shocks like German economy, the difference being most pronounced in case of Spain, Sweden and Poland. The results for hazard rates of labour market flows are more diverse, but in general German pattern of adjustment to shocks implies more stable behaviour of inflows to employment and more volatile outflows from employment than in other countries studied.

Table 4: Standard deviations of cyclical component of selected macroeconomic variables - model prediction, counterfactual simulation and data (in %).

	Czech Rep.	France	Greece	Poland	Spain	Sweden	UK
GDP							
German model	1.5	1.1	1.2	1.3	0.8	1.7	1.1
Country model	1.9	1.2	1.6	1.6	1.2	1.9	1.2
Data	1.8	1.0	1.6	1.3	1.1	1.9	1.2
Wages							
German model	1.4	0.9	3.6	4.2	4.1	2.9	1.3
Country model	1.1	0.5	2.5	1.7	0.8	0.8	0.6
Data	1.2	0.6	4.5	3.3	1.2	0.7	0.6
Employment rate							
German model	0.7	0.4	0.9	1.1	1.1	1.0	0.4
Country model	0.9	0.6	1.3	1.6	1.7	1.1	0.5
Data	0.8	0.5	1.4	1.4	1.5	1.1	0.5
Unemployment rate							
German model	4.8	2.9	6.0	7.5	7.7	6.5	2.6
Country model	7.4	4.0	6.6	6.1	7.6	8.4	3.8
Data	13.2	6.0	8.1	11.4	11.4	10.7	5.9
Hazard rate of outflow from employment							
German model	12.4	7.3	9.0	11.9	14.5	13.7	7.1
Country model	9.6	5.2	6.4	8.0	7.2	9.0	5.7
Data	15.7	5.8	6.4	8.6	7.8	9.7	6.2
Hazard rate of inflow to employment							
German model	5.0	3.5	8.2	6.7	7.3	7.1	5.3
Country model	5.2	3.4	6.4	6.4	5.0	6.7	5.9
Data	8.8	5.4	10.6	9.1	7.8	8.6	6.6
Source: own calculations based on the DSGE model and Eurostat data.							

We find that the United Kingdom exhibited the highest degree of similarity to Germany among all studied economies, as Figure 12 shows that predictions for all variables are almost identical for both models. Noticeable differences in reactions to shocks emerge in other countries. In particular, Figure 10 shows that in general the Spanish economy fared worse with the absorption of shocks than the German economy. However, after 2009, even German absorption mechanisms would not have allowed Spain to avoid a slowdown

- in terms of GDP the German economy would not have coped much better with such strong internal and external shocks as those affecting Spain. Nevertheless, the response of the labour market to the same shocks would be different in Germany - shocks that hit the Spanish economy would have had less effect on changes in unemployment and employment, but would have led to much larger fluctuations in wages in Germany. This means that compared with Germany, Spain had much higher wage rigidities and a greater role of quantitative adjustments in the labour market. Analogous, but less pronounced trade-off between the adjustment of wages and employment in comparison to the German economy is found for France, Czech Republic and Sweden (see Figures 6, 7 and 11).
Figure 8 shows that the shocks which affected Greece in Germany would have resulted in a decline of GDP by 50% lower than that recorded in Greece. However, they would have also produced a noticeable recession in Germany. Nevertheless, the decline in employment would have been significantly lower in Germany than it was in Greece, but we find that, contrary to Spain or France, it is not due to wage rigidities in Greece (as the path of wages and their standard deviations are very similar in both simulations) but rather to higher elasticity of employment with respect to GDP in Greece.
We also find that if the Polish economy had functioned in the German manner, it would have experienced a lower volatility on the labour market while maintaining the same GDP growth trajectory. According to Figure 9, the wages would not have risen so strongly in the boom years in 2006-2008 which would allow longer period of employment growth, the GDP would also be higher (and above the trend) in 2011-2012, allowing for higher wages, higher employment and lower unemployment than actually recorded. The Czech economy is found to be more sensitive to foreign demand shock than the German one, so its GDP (and employment) would have been lower in the boom of 2006-2007, but in the Great Recession the Czech Republic would have behaved similarly to Germany, because the main factor behind it was the (internal) productivity shock, and in this regard the responses of the two economies are found to be similar. Relatively small differences exist in the functioning of the labour market; nonetheless, if Germany had been subjected to shocks of the same strength as the Czech Republic, fluctuations in employment and unemployment rates would have been lower, and fluctuations in wages would have been higher (see Figure 6).
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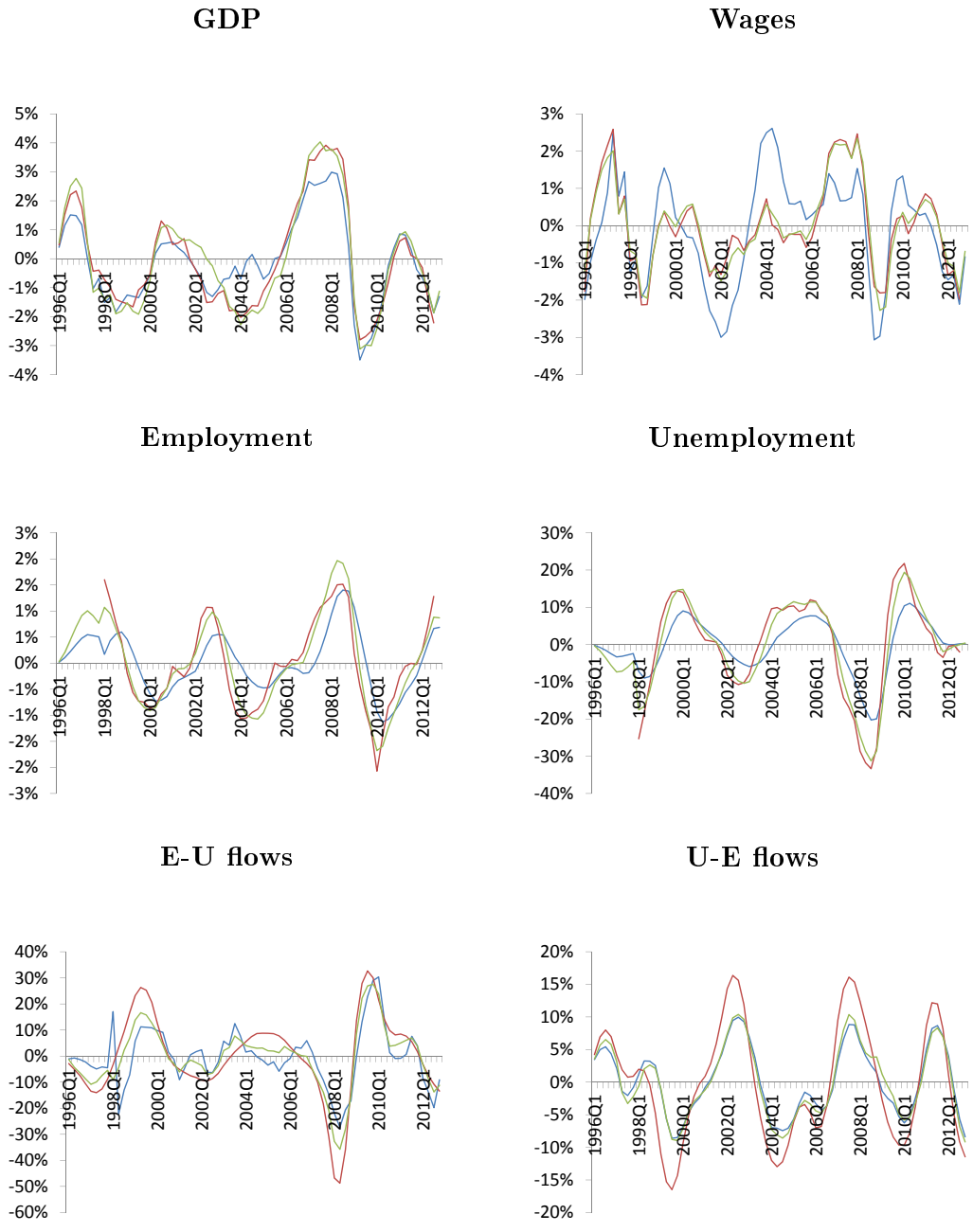
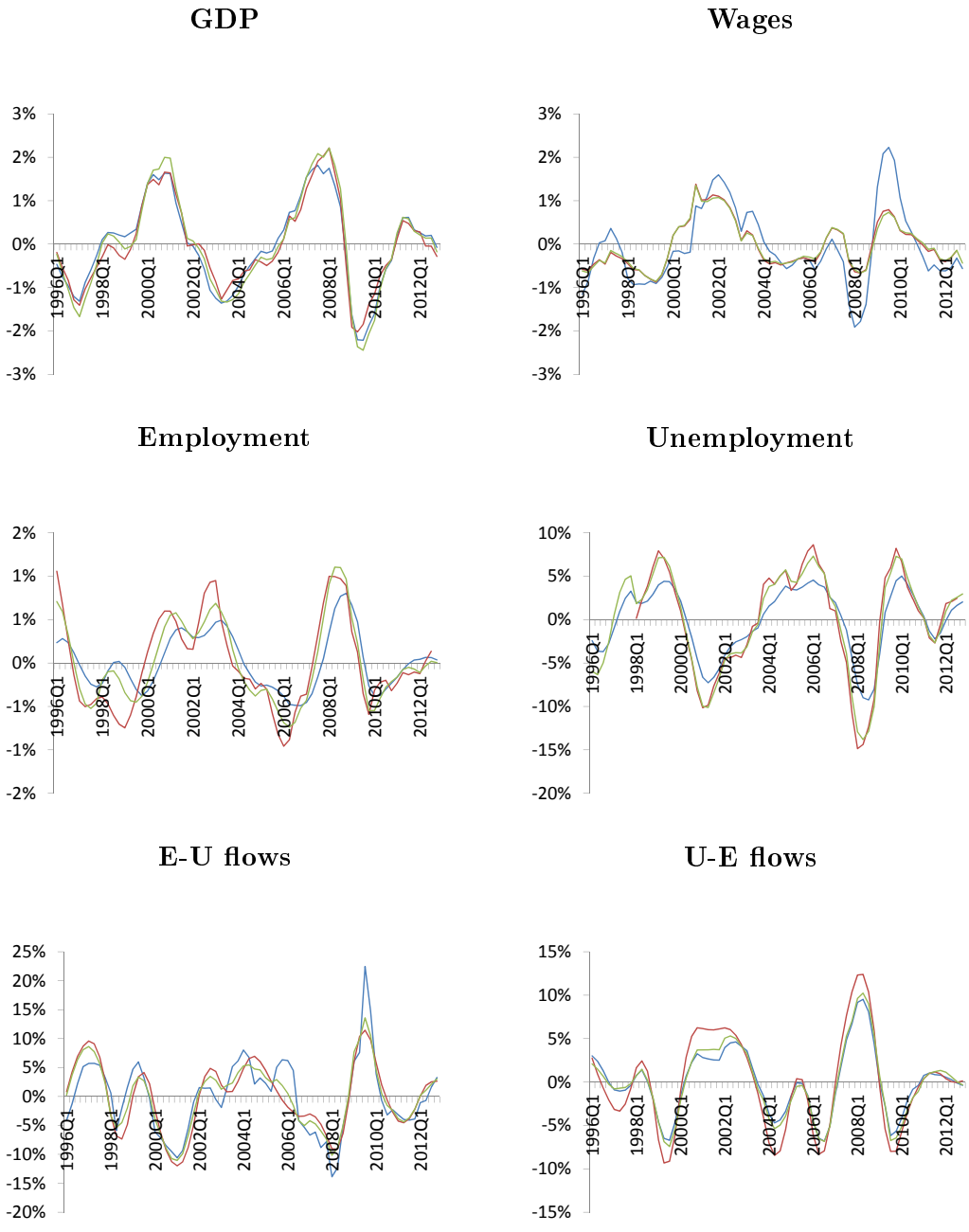
Figure 6: Comparison of the Czech Republic's capacity to absorb macroeconomic shocks against Germany.



blue line - German model, red line - data for country, green line - model for country

Figure 7: Comparison of France's capacity to absorb macroeconomic shocks against Germany.

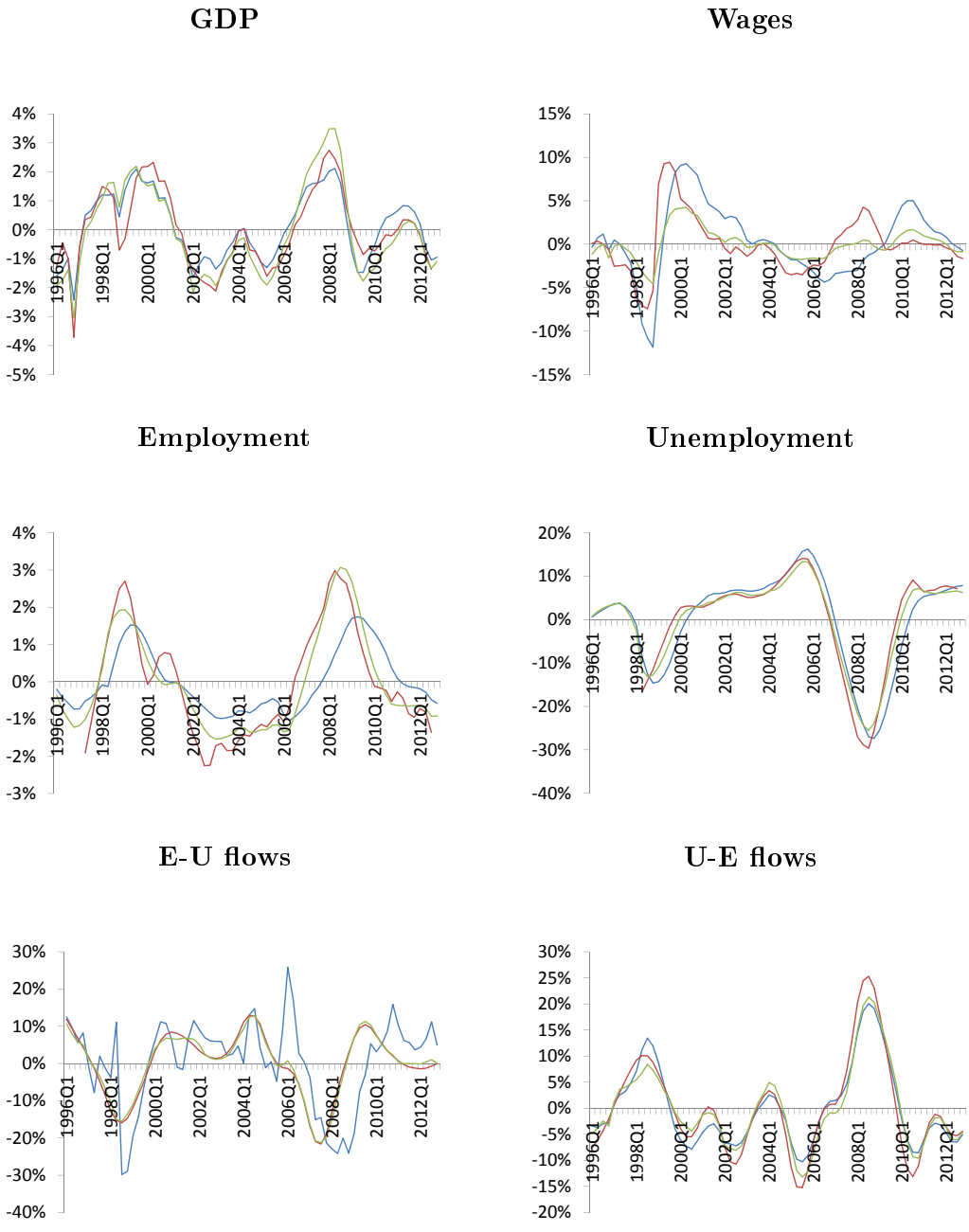


blue line - German model, red line - data for country, green line - model for country

Figure 8: Comparison of Greece's capacity to absorb macroeconomic shocks against Germany.

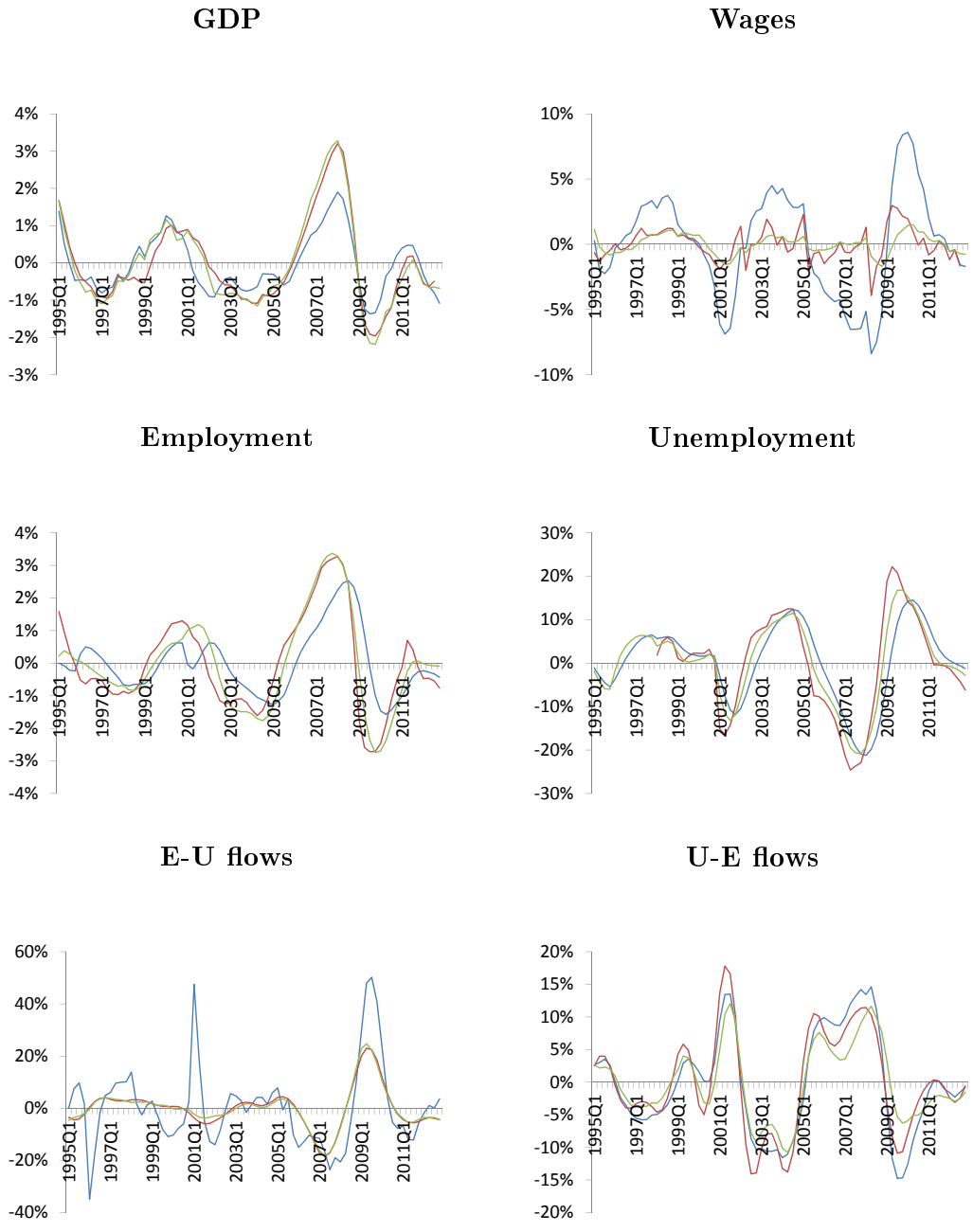
blue line - German model, red line - data for country, green line - model for country

Figure 9: Comparison of the Poland's capacity to absorb macroeconomic shocks against Germany.



blue line - German model, red line - data for country, green line - model for country

Figure 10: Comparison of the Spain's capacity to absorb macroeconomic shocks against Germany.

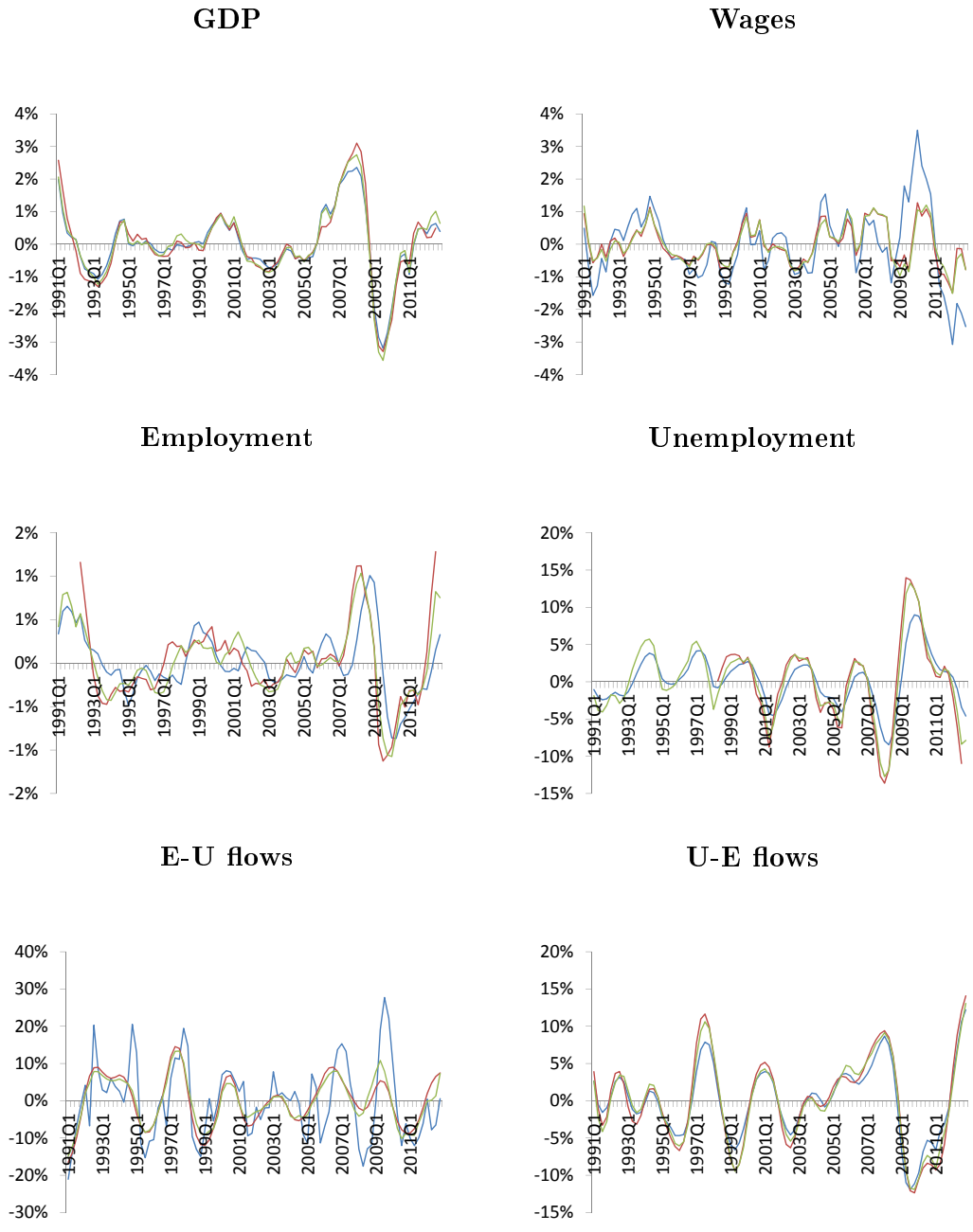


blue line - German model, red line - data for country, green line - model for country

Figure 11: Comparison of the Sweden's capacity to absorb macroeconomic shocks against Germany.

blue line - German model, red line - data for country, green line - model for country

Figure 12: Comparison of the United Kingdom's capacity to absorb macroeconomic shocks against Germany.



blue line - German model, red line - data for country, green line - model for country

4 Conclusions

In this paper we use a DSGE model of open economy with search on the labour market to identify the driving forces behind fluctuations of macroeconomic and labour market variables during the Great Recession. We estimate a separate model for eight European economies using a Bayesian procedure and the estimated models are able to replicate most of the variation observed in the data. We use a Kalman filter procedure to identify shocks which were the responsible for macroeconomic fluctuations in the analysed economies. The external foreign demand shock and the internal productivity shock are identified as the main determinants of fluctuations of GDP and its components. Private consumption is also found to be driven to a large extent by the job destruction shock. In some countries countercyclical fiscal policy worked to offset the negative impact of the Great Recession, however only to a small extent. The driving forces behind labour market variables: employment, unemployment, wages, hiring and firing probabilities are found to be much more diverse. The shocks that exerted influence on these variables were mainly job destruction, bargaining power, and foreign demand shocks, with some differences observed between countries.

Furthermore, we perform counterfactual simulations whose aim is to compare the ability to absorb shocks by different economies. We find that the German economy exhibited the highest resilience among the analysed countries and therefore is chosen as a reference point for other countries studied. We find that the fluctuations implied by the German model conditional on shocks estimated for other countries are smaller or of the same magnitude as implied by models for these countries. Nevertheless, we find that during the Great Recession even the German economy would face a significant slowdown if it was hit by negative shocks such as those which affected countries which suffered most, like Spain. However, even in that case the reaction of the labour market would be different. Our simulations suggest the trade-off between wage (price) and employment (quantity) adjustments on European labour markets - in Germany the reaction of wages would be larger, and reaction of employment and unemployment smaller than in other countries, in particular Spain, France, Czech Republic and Sweden.

This trade-off between wage and employment adjustments has possibly important consequences for the impact of recessions on societies, as the economies suffering from more job losses faced higher unemployment, poverty risk and social transfer spending. The literature argues that differences with respect to wage flexibility can be associated with differences in labour market institutions, like collective bargaining, minimum wage, active labour market policies or stringency of employment protection. Although further research to understand these links, especially during the turbulence and atypical policy responses during the Great Recession, is needed, our finding delivers an important hint for policy makers to concentrate their efforts on addressing poor wage flexibility with structural policies.

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