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Prediction with Spatial Panel Data: The Case of Regional Unemployment in Russia and Germany

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Motivation

- Variability of labor market aggregates is much higher across regions than across national economies (Overman & Puga, 2002; Elhorst, 1995)
- Reasons of interregional disparities are different from disparities between countries (Elhorst, 2004)

Motivation

- Unemployment disparities are inefficient (Taylor, 1996)
- Heterogeneity across regions requires policy measures targeted at the regional level
- Hence, the need for forecast at the regional level is rapidly increasing
- Regional labor markets are interconnected
- Spatial econometric techniques might represent a valid tool to improve forecast at the regional level.

Objective of the paper

investigate to what extent the introduction of spatial dependence into a panel data model affects the predictive accuracy of regional unemployment.

Regional economic forecasting. Main ideas

Lehmann R., Wohlrabe K. Regional economic forecasting: state-of-the-art methodology and future challenges. – 2014.:

“Over the last decade, the topic of regional economic forecasting has become increasingly prevalent in academic literature”

“Regional economic forecasting. It concentrates on two specific macroeconomic aggregates:

- (i) total output such as gross-domestic product (GDP) or gross-value added (GVA) and
- (ii) labour market variables like total employment or the unemployment rate”

“Spatial panel data models are becoming increasingly common practice in regional forecasting”

Main ideas in Literature

1. Time-series models, dynamic panel data models, spatial lags
   - Schanne et al. (2010): “When comparing the forecast precision with that of univariate time series methods, we find that the spatial model does indeed perform better”
   - Kholodilin et al. (2007), Girardin et al. (2011): “spatial effects help to substantially improve the forecast performance”
   - Mayor and Patuelli (2012): time series models work better than spatial models when the time dimension is higher than the cross section, when number of observations in time is not sufficient panel data models perform better
2. Using exploratory variables X
   - X are separated into training and validation set or lags of X are used: Longhi et al.(2005, 2007)
   - X are modeled for future periods (Gaidar Institute for Economic Policy)
   - Dynamic systems with spatial lags (Polasek, 2007)

Data

75 Russian regions
Russian Federation Federal State Statistics Service
www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/main/
370 German regions
Federal Statistical Office of Germany
www.statistikportal.de/Statistik-Portal/en/
Dependent variable - Regional unemployment rate
Period: 2005 – 2010 for the estimation
2011 - 2012 for the forecasting

Variables

Russia	Germany
Sectoral structure (share of employed people in sector)	
Agriculture, hunting and forestry; fishing, fish farming	Agriculture, forestry and fishery
Mining	-
Manufacturing	Manufacturing
Production industry (incl. manufacturing industry, except construction)	Production and distribution of electricity, gas and water
Construction	Construction
Wholesale and retail trade; repair of motor vehicles, motorcycles, household goods and personal items	Trade, hotels and restaurants, transport
Hotel and restaurants	Financial business, renting, business services
Transport and communication	-
Real estate operations, rent and services	-
Education	-
Medicine and social services	-
Other community, social and personal services	Public and private service provision

Variables

Russia	Germany
Education	
Higher education	University education
-	Professional education
-	without professional education (only school education)
Age structure	
Share of employed people between ages 15-19	-
Share of employed people between ages 20 - 29	Share of working age population (15-65) aged 15-25
Share of employed people between ages 60 - 72	Share of working age population (15-65) aged 50-65
Migration coefficient	Migration coefficient
Housing	-
-	Growth rate of employed population in a region
Number of registered crimes per 100 thousand people	-
GRP per capita in prices of year 2005, corrected for the purchasing power	GRP per capita, divided by consumer price index of a state, where region is located
Population density	Population density
Average monthly nominal wage	Average hourly wage in a region

Model specification

General model:

$$y_{it} = \rho W y_{it} + \gamma y_{it-1} + X'_{it}\beta + \mu_i + \phi_t + \epsilon_{it}$$

- Pooled regression: $\rho = \gamma = 0$, $\mu_i = \mu \; \forall$ i
- FE without spatial effects: $\rho = \gamma = 0$
- RE without spatial effects: $\rho = \gamma = 0$
- FE with spatial effects: $\gamma = 0$
- RE with spatial effects: $\gamma = 0$
- models without X: $\beta = 0$
- models without X and dynamics: $\beta = 0$, $\gamma = 0$

+ the same models without time effects

Spatial Matrices

Binary contiguity matrix

$$w_{ij} = \begin{cases} 1, \text{if } i \text{ and } j \text{ share a border} \\ 0, \text{if } i \text{ and } j \text{ do not have a common border} \end{cases}.$$

Matrix of inverse distances

$$W = \begin{pmatrix} 0 & \frac{1}{d_{12}} & \cdots & \frac{1}{d_{1N}} \\ \frac{1}{d_{21}} & 0 & \cdots & \frac{1}{d_{2N}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{d_{N1}} & \frac{1}{d_{N2}} & \cdots & 0 \end{pmatrix}.$$

Forecasting

General model:

$$y_{it} = \rho W y_{it} + \gamma y_{it-1} + X'_{it}\beta + \mu_i + \phi_t + \epsilon_{it}$$

Pooled regression:

$$\hat{y}_{it+s} = X'_{it+s}\hat{\beta} + \hat{\mu}$$

FE without spatial effect:

$$\hat{y}_{it+s} = X'_{it+s}\hat{\beta} + \hat{\mu}_i + \hat{\phi}_t$$

RE without spatial effects:

$$\hat{y}_{it+s} = X'_{it+s}\hat{\beta} + \frac{T\hat{\sigma}^2_\mu}{T\hat{\sigma}^2_\mu + \hat{\sigma}^2_\epsilon}\bar{\epsilon}_{i.} + \hat{\phi}_t$$

where $\bar{\epsilon}_{i.} = \sum_{t=1}^{T} \hat{\epsilon}_{it}/T$

Forecasting

FE with spatial effects:

$$\hat{y}_{it+s} = (I - \hat{\rho}W)^{-1} X'_{it+s}\hat{\beta} + (I - \hat{\rho}W)^{-1}(\hat{\mu}_i + \hat{\phi}_t)$$

$$\hat{y}_{it+s} = (I - \hat{\rho}W)^{-1}(\hat{\gamma}\hat{y}_{it+s-1} + X'_{it+s}\hat{\beta}) + (I - \hat{\rho}W)^{-1}(\hat{\mu}_i + \hat{\phi}_t)$$

RE with spatial effects:

$$\hat{y}_{it+s} = (I - \hat{\rho}W)^{-1} X'_{it+s}\hat{\beta} + (I - \hat{\rho}W)^{-1}\left(\frac{T\hat{\sigma}^2_\mu}{T\hat{\sigma}^2_\mu + \hat{\sigma}^2_\epsilon}\bar{\epsilon}_{i.} + \hat{\phi}_t\right)$$

where $\bar{\epsilon}_{i.} = \sum_{t=1}^{T} \hat{\epsilon}_{it}/T$
Naive predictors:

$$\hat{y}_{iT+s} = y_{iT+s-1}$$

$$\hat{y}_{iT+s} = \sum_{j=1}^{J=4} y_{i,T+s-j}/J$$

Measures of forecasting accuracy

Root mean squared error

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\hat{y}_{iT+s} - y_{iT+s}\right)^2}$$

Mean absolute percentage error

$$MAPE = 100\frac{1}{N}\sum_{i=1}^{N}|\hat{y}_{iT+s} - y_{iT+s}|/|y_{iT+s}|$$

Mean absolute error

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|\hat{y}_{iT+s} - y_{iT+s}|$$

Symmetric mean absolute percentage error

$$sMAPE = 100\frac{1}{N}\sum_{i=1}^{N}2|\hat{y}_{iT+s} - y_{iT+s}|/|\hat{y}_{iT+s} + y_{iT+s}|$$

Forecasting

Two cases:

- Use actual values X'_{it} for the prediction

$$y_{it} = \rho W y_{it} + \gamma y_{it-1} + X'_{it}\beta + \mu_i + \phi_t + \epsilon_{it}$$

- Forecast for one additional year using known values of a previous period X'_{it-1}

$$y_{it} = \rho W y_{it} + \gamma y_{it-1} + X'_{it-1}\beta + \mu_i + \phi_t + \epsilon_{it}$$

Performance of an out-of sample one-step ahead unemployment forecast for Russian regions, 2011

Table 2. Measures of forecast accuracy for 2011. Russian regions.

	Models without regressors				Non-spatial models with regressors					Spatial models												
	Naive (t-1)	Naive (mean)	Spatial model with FE	Dynamic model with FE	Pooled OLS	RE	FE	RE	FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE
Time effects	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes
Matrix	-	-	OP	-	-	-	-	-	-	ID	ID	ID	ID	ID	ID	B	B	B	B	B	B
All regions																					
RMSE	2,19	1,32	1,16	1,30	2,23	2,01	1,48	1,99	2,26	1,84	**0,99**	2,70	2,50	1,03	2,64	1,80	1,05	2,23	1,92	1,24	2,51
MAPE	29,13	14,11	11,23	13,74	29,83	28,68	15,23	23,26	28,49	21,07	**9,79**	36,82	36,51	11,19	38,46	20,34	10,57	28,08	26,35	12,86	36,24
MAE	1,77	0,97	0,82	0,96	1,82	1,64	1,08	1,52	1,86	1,39	**0,71**	2,34	2,30	0,80	2,44	1,37	0,76	1,81	1,67	0,92	2,31
sMAPE	23,83	13,03	10,66	12,59	24,58	22,95	13,83	19,83	23,77	18,18	**9,50**	29,52	29,51	11,56	30,98	17,74	10,00	23,36	22,25	11,90	29,46
Western regions																					
RMSE	2,11	1,34	1,22	1,28	2,02	7,07	1,32	2,61	3,64	1,61	**1,00**	3,27	3,40	3,22	1,50	1,69	**0,98**	2,30	2,34	3,10	1,54
MAPE	28,77	14,45	11,64	13,89	28,23	92,04	15,25	35,72	58,22	17,42	**12,01**	49,26	56,12	52,62	21,43	18,72	**11,23**	30,46	36,81	50,36	22,05
MAE	1,72	0,96	0,82	0,92	1,64	5,75	1,03	2,20	3,43	1,14	**0,78**	2,97	3,26	3,08	1,29	1,23	**0,75**	1,90	2,14	2,95	1,33
sMAPE	24,03	13,34	11,08	12,72	27,29	72,09	14,41	28,86	42,88	15,57	**12,75**	37,75	41,61	39,75	18,71	16,59	**11,02**	25,23	29,45	38,38	19,14
Eastern regions																					
RMSE	1,26	1,26	0,68	1,37	1,26	2,56	0,99	2,04	4,64	1,23	**0,54**	0,94	1,66	1,07	1,62	1,11	0,98	0,94	1,83	0,96	1,85
MAPE	12,83	13,35	4,56	13,99	13,08	31,29	9,94	23,53	59,15	13,24	**3,60**	9,51	19,51	10,83	17,92	11,92	5,11	8,75	21,98	8,89	21,32
MAE	0,96	1,01	0,35	1,08	0,95	2,28	0,75	1,80	4,52	1,01	**0,30**	0,78	1,48	0,85	1,39	0,93	0,46	0,73	1,66	0,72	1,63
sMAPE	12,03	12,33	4,30	12,73	12,28	26,54	9,27	27,79	89,02	12,11	**3,72**	9,55	22,28	10,05	20,46	11,12	5,06	8,53	25,46	8,48	24,84

Correction for the time effect is calculated as an average of four previous estimated time effects. ID – matrix of inverse distances, B – boundary matrix, FE – fixed effects, RE – random effects.

Performance of an out-of sample one-step ahead unemployment forecast for German regions, 2011

Table 4. Measures of forecast accuracy for 2011. German regions.

	Models without regressors				Non-spatial models with regressors					Spatial models											
	Naive (t-1)	Naive (mean)	Spatial model with FE	Dynamic model with FE	Pooled OLS	RE	FE	RE	FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE
Time effects	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes
Matrix	-	-	OP	-	-	-	-	-	-	ID	ID	ID	ID	ID	ID	B	B	B	B	B	B
All regions																					
RMSE	0,76	1,28	1,96	0,58	2,57	1,32	1,54	1,00	0,89	5,15	2,27	13,36	3,42	**0,45**	3,78	1,46	1,28	2,11	1,12	0,58	0,78
MAPE	13,97	19,97	32,46	7,64	44,38	23,20	26,23	14,60	12,28	105,28	46,17	268,43	66,80	**6,15**	75,64	26,93	23,29	38,58	17,85	7,97	14,32
MAE	0,67	1,09	1,78	0,42	2,09	1,10	1,22	0,79	0,68	5,11	2,21	13,35	3,38	**0,33**	3,76	1,24	1,08	2,00	0,97	0,42	0,70
sMAPE	12,70	17,74	27,32	7,81	33,78	42,75	21,07	13,14	11,33	164,75	63,91	109,00	48,33	**6,10**	173,08	28,32	36,03	31,31	15,90	8,37	13,02
Western regions																					
RMSE	0,73	1,00	1,63	**0,44**	1,88	1,13	1,24	1,59	1,55	2,25	1,09	3,47	2,34	**0,46**	5,43	1,15	0,94	1,57	1,80	0,49	0,53
MAPE	14,63	19,21	31,96	**6,69**	31,41	20,08	20,26	30,76	29,71	48,08	22,23	72,69	48,44	**7,22**	116,95	22,04	17,04	30,07	36,10	7,10	9,84
MAE	0,66	0,91	1,55	**0,33**	1,45	0,93	0,93	1,47	1,43	2,17	0,99	3,42	2,28	**0,35**	5,42	0,98	0,76	1,44	1,71	0,34	0,45
sMAPE	13,27	17,12	26,93	**6,53**	28,32	24,65	38,31	25,78	25,07	28,97	27,10	51,47	37,86	**6,96**	388,74	28,04	20,95	25,30	29,74	7,35	9,19
Eastern regions																					
RMSE	0,93	2,50	3,48	0,80	1,94	1,07	1,14	2,21	2,53	1,21	1,20	1,78	2,46	1,17	1,14	1,08	0,97	2,29	1,51	**0,78**	2,03
MAPE	9,29	25,34	35,98	6,57	15,94	9,24	9,09	21,53	25,06	10,54	10,51	16,58	24,72	10,68	10,72	9,29	7,69	22,40	14,05	**6,41**	20,84
MAE	0,80	2,39	3,40	0,64	1,47	0,85	0,85	2,05	2,39	0,99	0,99	1,60	2,36	1,02	1,00	0,85	0,72	2,14	1,35	**0,63**	1,94
sMAPE	8,63	22,10	30,03	6,87	15,05	9,95	9,78	19,09	21,91	11,52	11,43	15,03	21,71	11,49	9,99	10,05	8,17	19,80	12,91	**6,57**	18,55

Correction for the time effect is calculated as an average of four previous estimated time effects. ID – matrix of inverse distances, B – boundary matrix, FE – fixed effects, RE – random effects.

Performance of an out-of sample two-step ahead unemployment forecast for Russian regions, 2012

Table 3. Measures of forecast accuracy for 2012. Russian regions.

	Models without regressors				Non-spatial models with regressors					Spatial models											
	Naive (t-1)	Naive (mean)	Spatial model with FE	Dynamic model with FE	Pooled OLS	RE	FE	RE	FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE
Time effects	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes
Matrix	-	-	OP	-	-	-	-	-	-	ID	ID	ID	ID	ID	ID	B	B	B	B	B	B
All regions																					
RMSE	2,97	2,34	1,80	2,07	2,42	2,44	2,43	2,57	3,43	2,12	**1,48**	3,14	3,71	1,76	4,24	2,29	1,69	2,77	3,04	1,95	4,03
MAPE	51,04	40,89	26,69	32,16	42,26	38,82	36,32	41,86	57,28	32,61	**21,38**	55,73	68,71	29,86	78,62	36,05	24,40	47,34	54,12	27,34	74,03
MAE	2,55	2,09	1,42	1,67	2,02	1,98	1,99	2,12	3,07	1,68	**1,17**	2,79	3,53	1,48	4,02	1,85	1,35	2,38	2,80	1,53	3,79
sMAPE	36,95	31,78	22,21	25,80	31,39	30,11	30,70	31,93	42,00	25,96	**19,38**	40,03	48,10	27,81	52,68	28,24	20,90	35,14	40,16	22,92	50,44
Western regions																					
RMSE	2,76	2,37	1,60	2,18	2,06	2,07	1,80	3,15	4,89	1,58	**0,91**	1,83	3,91	3,43	5,14	2,01	1,14	1,84	2,96	1,58	4,92
MAPE	51,87	43,84	20,64	36,18	38,16	35,18	29,31	58,92	99,09	21,57	**13,33**	26,55	67,72	73,59	106,93	31,46	15,24	27,02	49,43	24,96	101,85
MAE	2,51	2,16	1,04	1,75	1,80	1,66	1,45	2,81	4,69	1,10	**0,58**	1,34	3,16	3,17	4,96	1,51	0,75	1,36	2,34	1,23	4,74
sMAPE	43,52	34,31	16,97	28,54	30,24	27,24	32,05	42,25	62,37	18,59	**-10,84**	21,91	42,68	74,40	65,05	24,79	16,07	22,21	34,32	26,79	63,01
Eastern regions																					
RMSE	1,75	1,86	0,83	1,86	1,61	1,53	1,58	1,71	3,98	1,57	**0,64**	1,02	1,13	1,54	1,48	1,53	**0,64**	1,07	1,33	1,45	1,83
MAPE	22,76	25,33	6,05	24,57	19,99	19,44	17,81	21,24	56,36	19,98	**4,02**	10,66	14,48	17,30	19,01	18,89	**3,92**	10,97	17,48	15,26	24,28
MAE	1,43	1,60	0,38	1,55	1,25	1,25	1,16	1,45	3,84	1,30	**0,26**	0,76	0,97	1,14	1,27	1,24	**0,26**	0,78	1,17	1,04	1,61
sMAPE	19,56	21,32	5,25	20,71	17,38	16,87	15,37	25,21	86,24	17,37	**3,60**	10,43	16,14	14,99	21,99	16,51	**3,53**	10,48	19,94	13,47	29,25

Correction for the time effect is calculated as an average of four previous estimated time effects. ID – matrix of inverse distances, B – boundary matrix, FE – fixed effects, RE – random effects.

Performance of an out-of sample one-step ahead unemployment forecast for Russian regions, 2013 X_{t-1}

Table 5. Measures of forecast accuracy for 2013. Russian regions.

	Models without regressors				Non-spatial models with regressors					Spatial models											
	Naive (t-1)	Naive (mean)	Spatial model with FE	Dynamic model with FE	Pooled OLS	RE	FE	RE	FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE
Time effects	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes
Matrix	-	-	OP	-	-	-	-	-	-	ID	ID	ID	ID	ID	ID	B	B	B	B	B	B
All regions																					
RMSE	**0,72**	1,77	1,83	1,05	1,53	1,14	1,25	1,27	1,62	1,00	1,15	1,13	1,88	0,77	**0,73**	1,10	1,20	1,09	1,67	1,03	0,75
MAPE	**10,09**	28,94	27,02	17,22	23,08	16,42	18,36	20,88	32,50	14,49	16,94	16,91	32,28	11,37	**11,09**	15,14	17,43	16,03	28,51	15,19	11,17
MAE	**0,55**	1,54	1,48	0,89	1,23	0,90	0,94	1,19	1,66	0,80	0,88	0,93	1,66	0,59	**0,57**	0,85	0,91	0,88	1,46	0,83	0,57
sMAPE	**10,21**	24,12	22,57	21,77	21,19	15,29	20,56	21,62	-117,78	15,32	18,39	19,43	22,68	11,33464	**11,58**	14,16	17,82	17,81	9,97	17,73	11,36
Western regions																					
RMSE	**0,68**	1,84	1,92	1,09	1,37	1,04	1,26	1,05	1,52	1,01	1,62	1,10	2,40	**0,86**	0,99	1,06	1,31	1,14	1,84	1,28	0,86
MAPE	**10,54**	31,51	29,03	20,48	22,24	15,71	20,76	16,56	28,06	16,02	30,27	18,32	45,52	**13,61**	17,98	16,24	22,29	18,53	34,30	20,41	15,20
MAE	**0,53**	1,59	1,54	0,95	1,13	0,82	0,95	0,84	1,30	0,80	1,41	0,88	2,15	**0,65**	0,86	0,83	1,05	0,91	1,60	1,05	0,73
sMAPE	**10,84**	25,99	24,20	27,09	25,16	15,70	29,63	17,63	-134,80	16,32	6460,58	19,94	46,38	**12,76**	22,31	15,87	30,81	19,12	8,20	24,77	17,81
Eastern regions																					
RMSE	**0,81**	1,60	1,61	4,48	1,44	1,28	1,50	0,98	0,98	0,90	1,14	**0,84**	0,86	1,12	0,95	0,93	1,19	0,85	0,88	1,12	1,10
MAPE	**9,06**	23,12	22,46	65,89	19,54	21,32	27,13	12,76	12,73	10,96	15,16	**10,73**	9,32	14,51	10,33	11,02	15,71	10,83	9,37	14,51	11,86
MAE	**0,60**	1,42	1,32	4,41	1,18	1,18	1,39	0,76	0,77	0,70	0,94	**0,65**	0,65	0,91	0,76	0,72	0,98	0,67	0,66	0,91	0,89
sMAPE	**8,80**	19,89	18,89	104,37	17,02	19,82	32,10	11,41	11,85	10,12	13,73	**9,86**	9,18	13,23	10,90	10,16	14,14	10,00	9,33	13,23	12,87

Correction for the time effect is calculated as an average of four previous estimated time effects. ID – matrix of inverse distances, B – boundary matrix, FE – fixed effects, RE – random effects.

Performance of an out-of sample

one-step ahead unemployment forecast, X_{t-1} Germany 2012

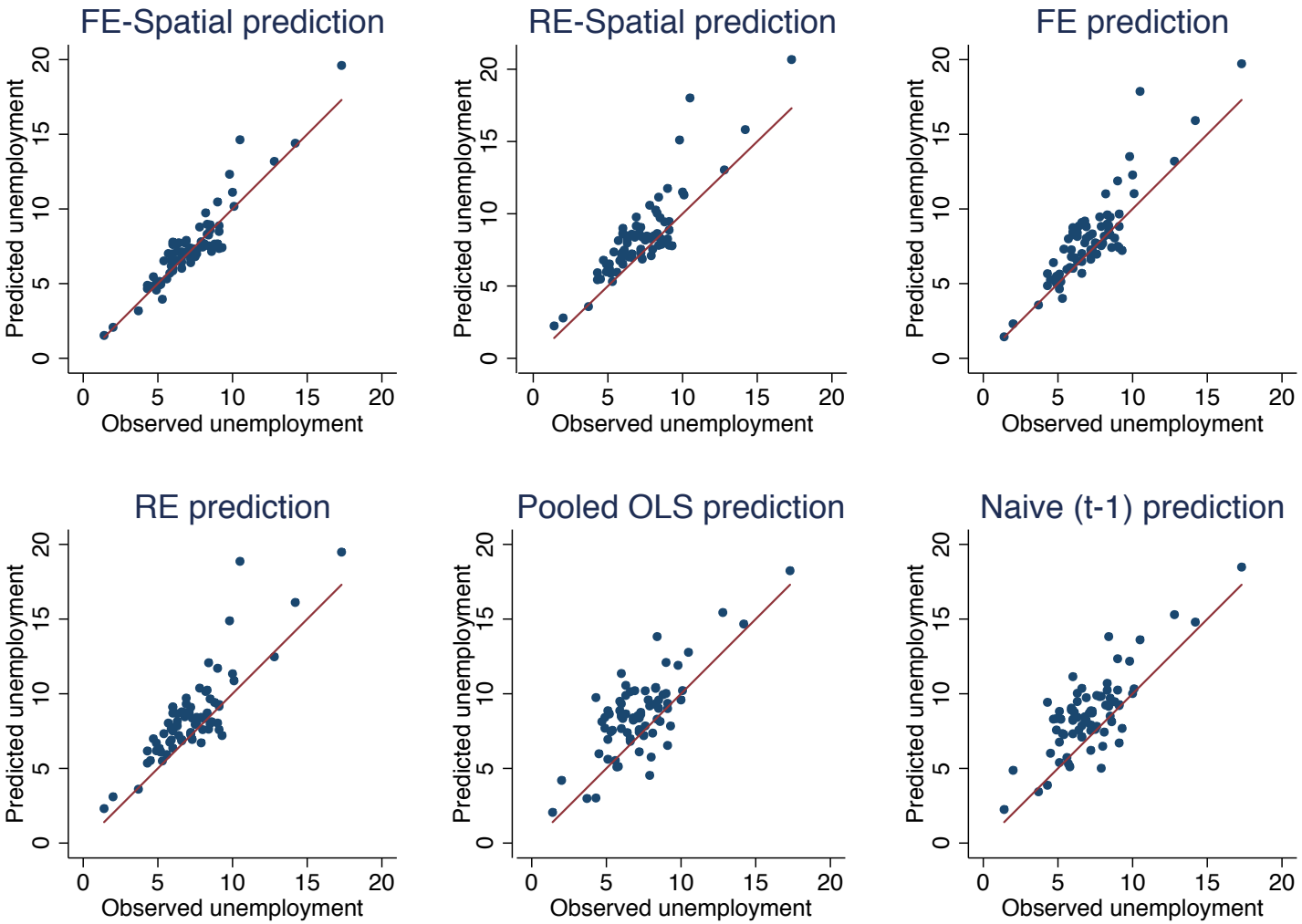
Table 6. Measures of forecast accuracy for 2012. German regions.

	Models without regressors				Non-spatial models with regressors					Spatial models											
	Naive (t-1)	Naive (mean)	Spatial model with FE	Dynamic model with FE	Pooled OLS	RE	FE	RE	FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE	RE	FE	RE	FE	Dynamic model with FE	Dynamic model with FE
Time effects	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes
Matrix	-	-	OP	-	-	-	-	-	-	ID	ID	ID	ID	ID	ID	B	B	B	B	B	B
All regions																					
RMSE	**0,34**	0,95	2,16	0,74	2,27	0,70	1,33	2,88	2,64	4,15	1,22	10,35	1,67	0,49	5,90	0,80	0,84	2,86	3,13	0,52	**0,39**
MAPE	**4,25**	15,11	36,35	14,20	40,43	10,09	24,29	59,67	54,60	87,50	24,73	217,13	34,63	7,83	122,65	14,40	14,15	60,08	65,88	8,22	**5,76**
MAE	**0,24**	0,80	1,94	0,67	1,84	0,53	1,09	2,82	2,57	4,12	1,11	10,33	1,57	0,39	5,89	0,66	0,67	2,80	3,06	0,41	**0,31**
sMAPE	4,13	13,75	30,00	15,87	31,45	10,44	51,71	107,53	87,26	211,41	32,69	275,41	2,40	8,25	885,70	16,98	16,98	108,33	139,64	8,74	**5,95**
Western regions																					
RMSE	**0,31**	0,76	1,79	1,05	1,69	0,95	1,03	2,35	2,15	1,39	0,72	0,55	0,58	0,53	4,95	0,62	0,71	2,26	2,73	0,46	**0,40**
MAPE	**4,22**	14,60	35,64	20,67	28,79	17,84	18,86	51,76	47,37	30,06	13,89	9,84	9,87	9,86	110,23	11,23	12,21	49,83	60,71	8,12	**6,85**
MAE	**0,22**	0,67	1,68	0,95	1,30	0,80	0,82	2,30	2,09	1,31	0,61	0,45	0,46	0,44	4,94	0,51	0,56	2,20	2,67	0,37	**0,32**
sMAPE	4,09	13,32	29,48	18,28	25,57	21,08	23,88	73,10	160,03	39,04	15,66	10,49	10,30	10,63	344,71	12,21	13,46	66,68	105,22	8,58	**7,18**
Eastern regions																					
RMSE	**0,52**	1,78	1,46	0,61	1,67	1,15	1,12	3,62	4,24	0,80	0,78	2,65	3,18	0,98	0,91	0,94	0,96	3,43	3,82	0,84	**0,80**
MAPE	**4,52**	18,66	5,86	5,52	14,06	11,00	10,98	39,21	46,32	6,90	6,28	28,18	34,45	9,50	8,73	8,11	8,05	37,15	41,70	7,96	**5,91**
MAE	**0,44**	1,68	0,54	0,51	1,28	0,94	0,94	3,54	4,17	0,64	0,60	2,54	3,08	0,84	0,77	0,75	0,74	3,34	3,73	0,69	**0,57**
sMAPE	4,39	16,76	4,78	5,69	13,84	12,20	12,07	51,01	63,74	7,13	6,25	34,03	43,51	10,18	9,27	7,90	7,97	47,77	55,80	8,36	**5,65**

Correction for the time effect is calculated as an average of four previous estimated time effects. ID – matrix of inverse distances, B – boundary matrix, FE – fixed effects, RE – random effects.

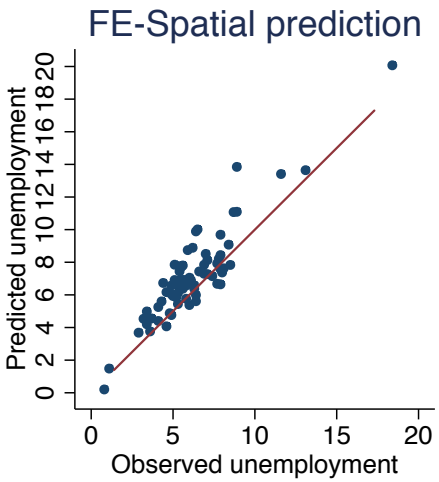
Performance of an

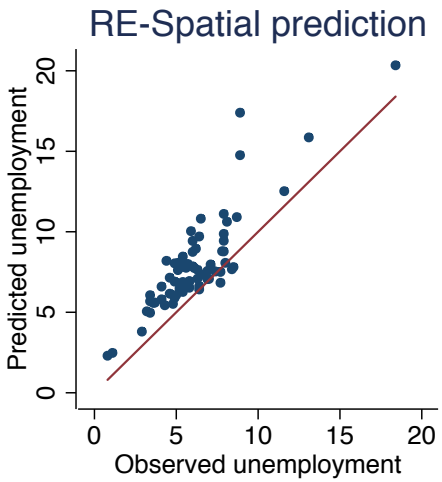
out-of sample one-step ahead unemployment forecast, Russia 2011

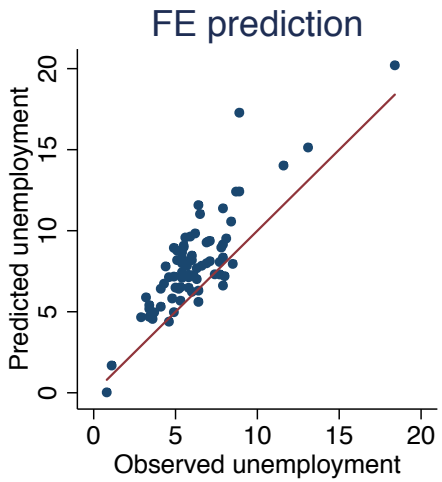


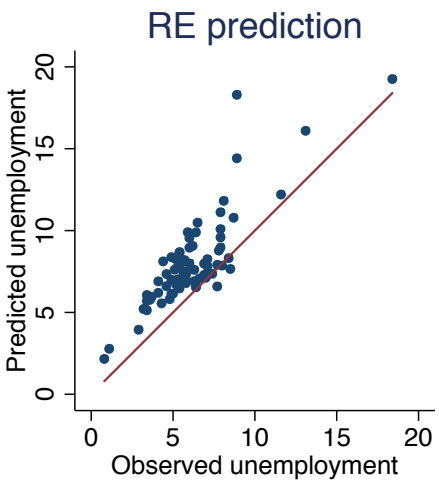
Performance of an

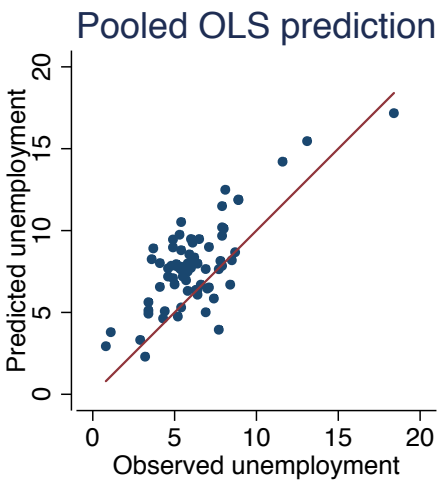
out-of sample two-step ahead unemployment forecast, Russia 2012

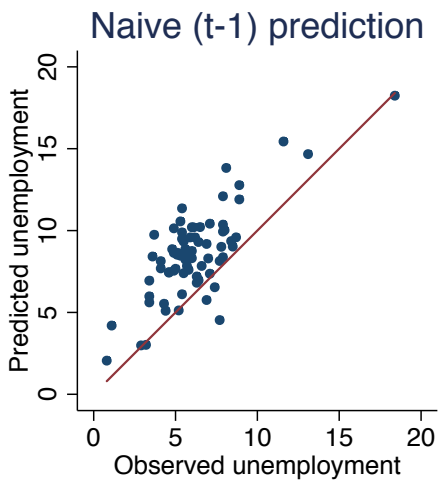






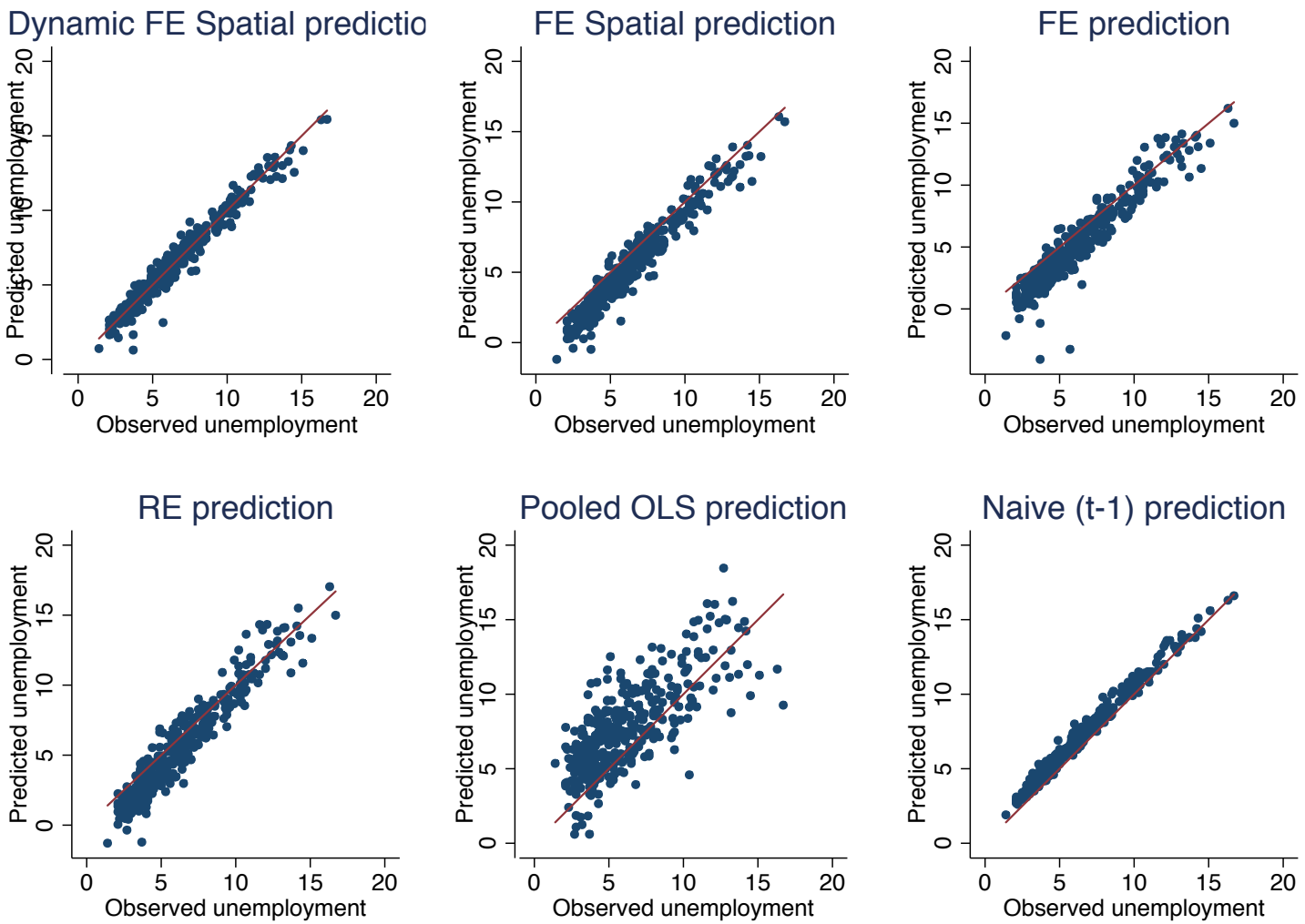






Performance of an out-of

sample one-step ahead unemployment forecast, Germany 2011



Conclusion

- We showed that adding spatial structure substantially increases the forecasting accuracy
- Accounting for spatial dependence allows panel data models to compete with ”strong” temporal dimension and give better forecasting accuracy than temporal ”naive” prediction

Thank you for your attention!

Prediction with Spatial Panel Data: The Case of Regional Unemployment in Russia and Germany

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