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Traffic Sensitivity of Long-Term Regional Growth Forecasts

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Abstract

We estimate the sensitivity of the regional growth forecast in the year 2002 resulting from changes in the travel time (TT) matrix. We use a dynamic panel model with spatial effects where the spatial dimension enters the explanatory variables in different ways. The spatial dimension is based on geographical distance between 227 regions in central Europe and the travel time matrix based on average train travel times. The regressor variables are constructed by a) the average past growth rates, where the travel times are used as weights, b) the average travel times across all regions (made comparable by index construction), c) the gravity potential variables based on GDP per capita, employment, productivity and population and d) dummy variables and other socio-demographic variables.

We find that for the majority of the regions the relative differences in growth for the year 2020 is rather small if the accessibility is improved. But there are differences as how many regions will benefit from improved train networks: gross domestic product (GDP), employment, and population forecasts respond differently.

Keywords: Dynamic panel models, long-term growth forecasts, BMA, traffic sensitivity analysis, road and train travel times

JEL Classification: R1, R41, L92, C21

1. Introduction

Long-term forecasting is a big challenge for the regional modelling, since only a few years of panel data are available on a regional basis. Furthermore, traffic dependent models must be developed to explore the sensitivity of travelling times

[1] The computations have been made by H. Berrer as part of the SIC project.

on the socio-demographic variables of a region. Using the sophisticated model choice procedure BMA (Bayesian model averaging, see Raftery et al. 1997) for the entire regional data set we have successfully reduced the pool of variables and we are able concentrate solely on demo-economic variables with traffic related backgrounds.

We consider two types of forecasts (with or without country-wise adjustments) and 2 railway TT scenarios: scenario 1 assumes that all presently planed projects (i.e. for the decade 2000–2010) will be realized according to the national traffic plans. Scenario 2 assumes railway investments that will remove all in the year 2000 known bottlenecks in the decade from 2010 to 2020.

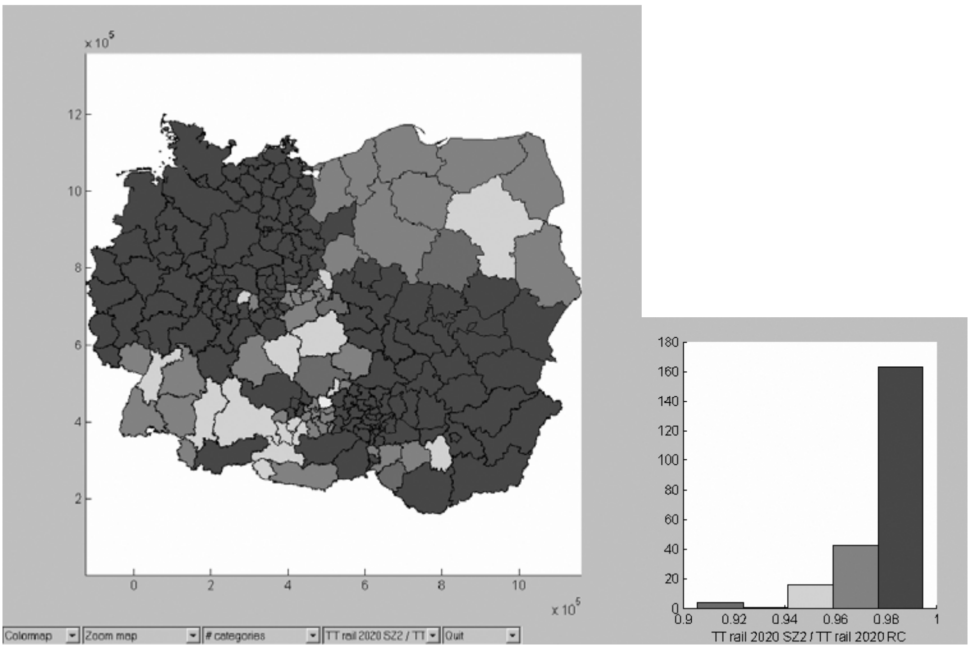
We will forecast the main economic characteristics of a region, namely the GDP growth rates, the employment rate and the population growth rate. The population growth rates forecast are compared with middle scenario ÖROK forecasts in the appendix, and surprisingly we find only small differences (the maximum is 0.5%) between this long-term demographic projection method (based on 100 age classes and constant fertility assumptions) and our panel base forecast. The comparison is shown for the SIC regions in the appendix B.

In the remaining section 1 we introduce the regional modelling approach and in Section 2 describe the traffic dependent GDP growth model. We define all the "spatial" related regressor variables that pick up the space and traffic interactions between all regions. Then we present the sensitivity analysis based on the long range forecast and the traffic improvement scenario 2. Section 3 and 4 extends this approach to the modelling and forecasting of the employment growth rate (EMPL%) and the population growth rate (POP%). A final section concludes.

Chart 1 shows the travel time reductions based on railway investment programs in 6 countries (Austria, Germany, Poland, Czech Republic, Slovakia and Hungary). They are based on the research work of an Interreg 3b project (SIC![2]) and are made available by the company BVU (www.bvu.de). From chart 1 we see that the largest travel time reduction can be expected for the Czech regions (Liberec and Jihorosky), the Hungarian regions and for the Polish region Lodzkie. (Note that the minimal ratios of TT reductions in chart 1 lie between 0.90 and 0.92 and indicate up to 8% to 10% faster travel times). The main problem of the TT reduction lies in the spatial distribution of the improvements. It is not the focus corridor between Berlin and Budapest that gets the highest improvements, but the orthogonal axis from Warsaw across Prague to Munich. This will be the reason for some of the counterintuitive results in the estimation results of the paper.

[2] SIC! SUSTRAIN Implement Corridor, an Intereg 3b project. http://www.sustrain-ic.net/

Chart 1: The Percentage of Travel Time Reduction between the Two Train TT Scenarios, i.e. TT1/TT2



Note: Scenario 1 (TT1 or current planning state: "reference case") and Scenario 2 (TT2 or improved railway connections: "free train"). Legend of the histogram: 5 classes of reduction from 0.9 (10% reduction) to 0.98–1.0 (small reduction).

Two types of forecasting methods were used: a) adjusted forecasts: growth in all regions of a country was restricted so that an average predicted growth was maintained in each country and b) unadjusted forecasts: growth prediction without country-specific restrictions.

1.1 The Regional Growth Model

The econometric model uses a dynamic panel model and data set for period 1995–2001 in 227 regions of 6 countries, where the main focus regions are located between Berlin and Budapest and consists of Nomenclature of Units for Territorial Statistics (NUTS)-3 regions, while most of the regions outside this proposed new traffic corridor are measured at NUTS-2-level. We use a Barro and Sala-i-Martin (1995) type growth regression model allowing for convergence, where the convergence terms are measured by the levels of the dependent variables, GDP, employment (EMPL) and population (POP) in the year 1995 (i.e. the first year of the data base of the present study). The dependent variable is the growth rates for the 3 focus variables: (real) regional GDP growth (GDP%, discounted by the national inflation rate), the employment rate (EMPL%) and the population growth rate (POP%).

We started with a traditional spatial model with up to 6 nearest neighbours, but we soon found out that – for traffic purposes – the transformation to special (= spatial) regression variables has more explanatory power. These linear and non-linear transformations are possible in our case since we obtained travel time (TT) matrices for train and road networks between all 227 regions. In the BMA analysis all the newly created TT and traffic variables were selected more often than traditional spatial variables, based on neighbourhood (continuity) or distance (nearest neighbours).

The following groups of explanatory variables were used in the forecasting model and in the preceding model choice procedure (BMA, see Raftery et al. 1997):

Travel times (TT) between 227 regions for the year 2000 (in the matrix TT1) and the year 2020 (in the matrix TT2).

Average travel times: a) average TT, b) weighted TT: with distance ("Far index") and with inverse distance ("Near index"), c) harmonic means, d) speed averages.

Accessibility indices: Based on the TT on road and on train we calculated an index with minimum 0 and maximum 1. This index is constructed either for the whole area (all) or the normalization in each country.

Potential indices: based on the gravity formula of Newton A*B/ D, where A and B denote the variables for the origin region and destination regions, and D is a distance measure. The following variables were used: GDP, GDP per capita (pc), employment, population, productivity: GDP per worker (pw)[3].

Infrastructure variables: a) the number of highway entrances per highway (Autobahn) km, b) the number of railway stations per rail km, c) the length of highway net per square-km and the length of railway net per square-km.

TT adjusted growth rates: Only past average weighted growth rates were calculated where we used the train TT or the road TT as weights.

1.2 The Sensitivity Analysis

The sensitivity analysis is needed to show the dependence of the regional growth rates on the TT of the variables on the right hand side that enter in linear and non-linear form. For the sensitivity analysis we use the models estimated by the BMA method since we selected trough this method the best regressor variables using the Scenario 1 rail travel times. With this model we calculate iteratively the future

[3] The exact formula is $x_i = \Sigma_j a_i b_j / d_{ij.}$

growth rates and the level of the dependent variable in the model until the year 2020. (Note that the model is specified in a causal way, i.e. no contemporaneous regressor variables are allowed.) The alternative forecasts for Scenario 2 are calculated in the same way. Finally, we compare both forecasts for the year 2020 and calculate the difference as percent of the Scenario 1 forecasts. These differences are plotted by geographical maps to see where the strongest positive and negative effects can be expected. This approach is called the unadjusted sensitivity analysis.

We derived also an “adjusted” sensitivity analysis, by looking at the country averages of forecasts and then we demand that the pattern of changes of the forecast model is zero over all regions within a country. This approach shows a sensitivity pattern without international boundary spill-over that means all push and pull effects of growth rates are equalized in each country.

1.3 Caveats

To make the results of the sensitivity analysis visible we have employed statistical maps as a graphical visualisation technique for the 227 regions. The advantage is that a large amount of data information can be understood faster than studying tables, but the disadvantage is that graphics stir up many more questions of the type “Why do we see these differences?” Thus, we have to warn the reader that not all of these questions can be answered satisfactory. Some differences will be due to occasional bad regional observations or data quality, some due to misfits of the model and some will be just unexplainable. We have followed the rule that the total graph has to reflect and present a sensible picture to justify our modelling approach.

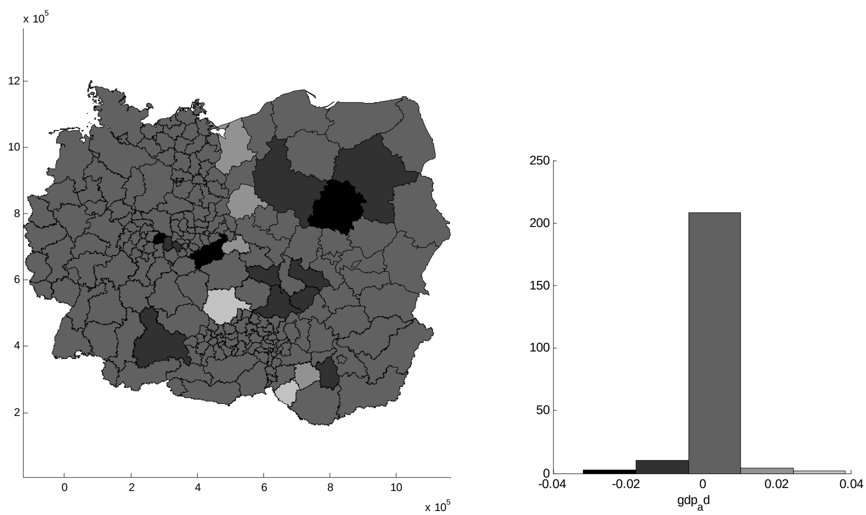
Furthermore we want to emphasize that we focus on a regional model where the regressor selection was done in such a way as to maximize the possible influence of train TT. This approach was chosen, since it was clear that traffic impacts, especially for train travel times on growth will be generally small. Thus, an “optimal regional growth model” will probably give slightly different results; also a model that will be based solely in road travel times or both. (Note that the interaction between the road TT and train travel times needs also some special studies).

Therefore we recommend regarding our study as a magnifying glass of train TT on regional growth patterns, while the other (observed and non-observed) factors are more or less kept constant.

2. The GDP Growth (GDP%) Model with Spatial Traffic Interactions

The sensitivity analysis of the travel time induced GDP forecasts for the year 2020 is shown in chart 2a for the adjusted model and for the un-adjusted model in chart 2b.

Chart 2a: The Adjusted Model: The Differences between GDP Levels for 2020 is Computed in Percent. The Majority of Regions Will only See a Slight Positive Train Travel Time Effect.



Legend: grey: no growth, dark grey: negative growth, light grey: positive growth.

Summary of the sensitivity analysis for the adjusted model: Out of 227 regions there were 86 regions with negative growth, 23 with zero growth and 118 with positive growth effects.

A regional map of the sensitivity analysis is shown in chart 2a for the scenario "free trains" (i.e. all major railway bottle necks will be removed) given by the matrix TT2 in comparison with the present (planned and realized 2000–2010) rail travel times, given by the matrix TT1. Let us denote by GDP2020(TT1) the GDP forecasts for the year 2020 by the TT1-matrix and GDP2020(TT2) for the TT2-matrix. We have plotted the Diff_GDP variable, i.e. the relative change of the GDP levels for 2020 based on 2 train travel time matrices, according to the formula:

$$Diff\_GDP = (GDP2020(TT2) - GDP2020(TT1)) / GDP2020(TT1).$$

Most positive changes in the regional GDP can be seen for the region Jena (in Eastern Germany) and those regions of the Czech Republic (e.g. Karlovarsky), which borders Germany, but also for Moravian regions (Moravskoslezsky and Olomoucky) bordering Poland. The largest negative growth impulse can be seen for the southwestern Hungarian region Zala, which is peripheral within Hungary and can move the growth towards regions closer to Budapest. Also some peripheral regions in Poland (Szczecinski, Nowosadecki) might slightly suffer due to lack of train TT improvements. Most German regions are not affected, and in Austria only those regions (that border Germany) are above zero growth.
From table 1b we see the top and low ten regions with traffic related growth differences from the unadjusted model. Surprisingly we see well-known larger cities, like Prague, Dresden, Frankfurt (Oder), Pest and Györ. Note that we see from the top 10 list that only 7 regions have a positive traffic impact: 3 from Poland and 4 from Slovakia.

Table 1: Scenario Sensitivities: The Top and Low Region of GDP Growth Rate Differences 2020

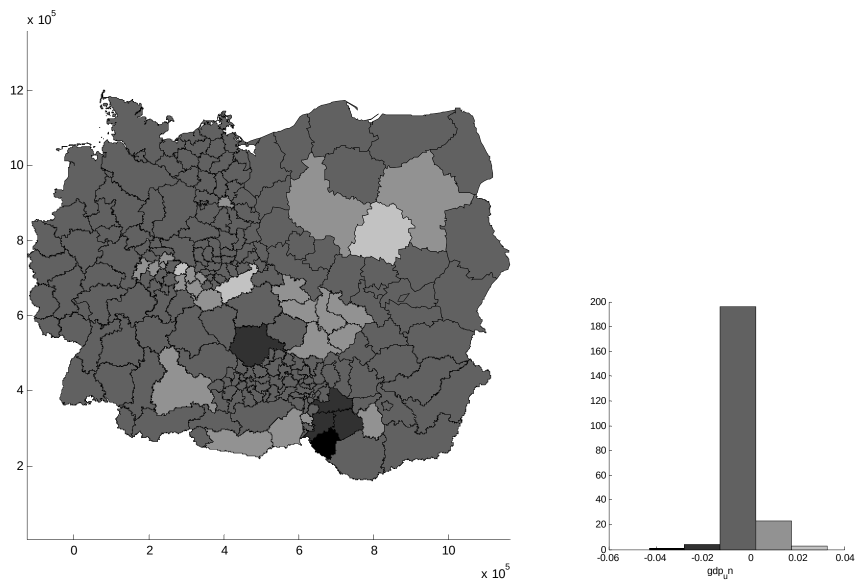
a) From the adjusted model

Zala	–0.036	Jena	0.022
Praha	–0.016	Lodzkie	0.022
Szczecinski	–0.014	Zlinsky	0.026
Nowosadecki	–0.014	Karlovarsky	0.027
Podkarpackie	–0.013	Moravskoslezsky	0.028
Kujawsko-Pomorskie	–0.013	Liberecky	0.046

b) From the unadjusted model

Low 10		***Top 10***	
Zala	–0.059	Oberwart	–0.003
Praha	–0.037	Vysocina	0.000
Stredocesky	–0.032	Jena	0.000
Pest	–0.027	Zlinsky	0.004
Dresden	–0.027	Wielkopolskie	0.005
Vas	–0.027	Karlovarsky	0.005
Cottbus	–0.027	Moravskoslezsky	0.006
Gyor-Moson-Sopron	–0.027	Mazowieckie	0.013
Del-Dunantul	–0.027	Lodzkie	0.024
Frankfurt (Oder)	–0.027	Liberecky	0.024

Chart 2b: Scenario Sensitivities of the Unadjusted Model: GDP Growth Sensitivities: Only a Few Regions Will Benefit from Improved Train Travel Times.



Colour legend: dark grey: negative growth, light grey: positive growth.

Summary of the sensitivity analysis for the unadjusted model: Out of 227 regions there were 218 regions with negative growth, 2 with zero growth and 7 positive growth effects.

Note that the results of chart 2b are rather pessimistic with respect to train TT changes. This might be a consequence of the declining GDP growth rates during the observation period, which leads to depressed long-term forecasts. The next table 2 summarizes the BMA estimates for the GDP% model.

From table 2 we see that the BMA estimate for the constant is not significant, and the Slovakia dummy variable is the only fixed effect that is negative (–2.1%). That means that Slovakia has a –2.1% base line handicap for regional growth, on average in our model. Slovakia needs strong positive impulses from other variables to overcome this GDP growth handicap compared with the other 5 countries. The convergence effect for the log GDP level is negative (Lgdp.1995: –.011), but the level effect of (log) population is positive (Lpop.95: .01).

Table 2: The GDP Growth Model and Spatial Traffic Variables (BMA Estimates)

Bayesian Model Averaging Estimates	Nobs= 227,	Nvars = 20	
Dependent Variable GDP%:	Average GDP	growth rates	(1995–2001)
R-squared = 0.886			
nu,lam,phi = (4, .25,3))	ndraws = 25000		
# models visited	= 2249		
*****************************	Posterior Estimates		
Variable	Coefficient	t-statistic	t-probability
const	–0.017	–0.9	0.35
Lgdp.1995	–0.011	–8.4	0.00
Lgdp.giTT.rail.96	–2.289	–5.5	0.00
Lgdp.giTT.rail.97	–0.024	0.0	0.98
Lgdp.giTT.rail.98	0.059	0.3	0.74
Lgdp.giTT.rail.99	–0.003	0.0	1.00
Lgdp.giTT.rail.00	0.086	0.3	0.76
Lpop.95	0.009	7.6	0.00
Lempl.00.95	0.388	7.7	0.00
Lpop.00.95	0.289	4.2	0.00
nodes.per.highway.km	0.015	2.9	0.00
TT.train.far	0.176/1000	11.7	0.00
acc.all.bahn.dist.avg	0.048	12.2	0.00
potential.gdp.empl.00.95.rail	0.123	9.0	0.00
potential.all.empl.95.rail	0.015	5.4	0.00
potential.all.gdp.cap.00.95.rail	0.153	11.3	0.00
d.aut	0.000	0.0	0.96
d.sk	–0.021	–7.2	0.00
d.hu	0.000	0.0	0.97
d.ger	0.000	–0.2	0.81
d.pl	–0.001	–0.4	0.71

The coefficients of the past POP and EMPL growth rates are both positive and between 0.29 and 0.39: this implies that a 3 % growth rate in either employment or population will result in a 1 % larger GDP growth rate.

Three out of the 5 inverse-TT weighted past EMPL growth rates are negative, and all of them are rail TT effects. The sum of these effects is – 2.2 that show a strong negative time dynamic component that was observed for GDP growth in the late 1990s. The long distance weighted TT variable for railways and the accessibility index based on train TT (acc.all.bahn.dist.avg: 0.048) have a positive influence and might be interpreted as a good transportation proxy variable (TT.far.train: 0.176). All potential variables have a positive effect, and all are based on rail TT. A significant potential effect is found for the change of the GDP per capita (potential.all.gdp.cap.00.95.rail), for productivity changes (GDP/ employment: potential.gdp.empl.00.95.rail), and for the employment potential (potential.all.empl.95.rail).

3. The Employment Growth (EMPL%) Model with Spatial Traffic Interactions

The Bayesian model averaging estimates for the EMPL% model are given in table 3:

From table 3 we see that the R^2 is 0.85 and quite high. The intercept is 2% and not different from zero: this shows that the regressors of the model are able to explain much of the GDP growth variation (and a little insignificant constant is present). Concerning the country fixed effects, only Slovakia is significant and has on average a 2.4% higher growth in employment. The convergence coefficient of the log employment level (Lempl.95) is significant and negative as expected, while the level effect of log GDP (Lgdp.95) is positive and about the same size as the initial employment (Lempl.95) coefficient. The coefficients on the GDP and population growth rates (Lpop.00.95, Lgdp.01.95) are both positive and almost 0.5: This implies that a 2% growth rate in GDP or population will result in a 1% larger EMPL growth rate.

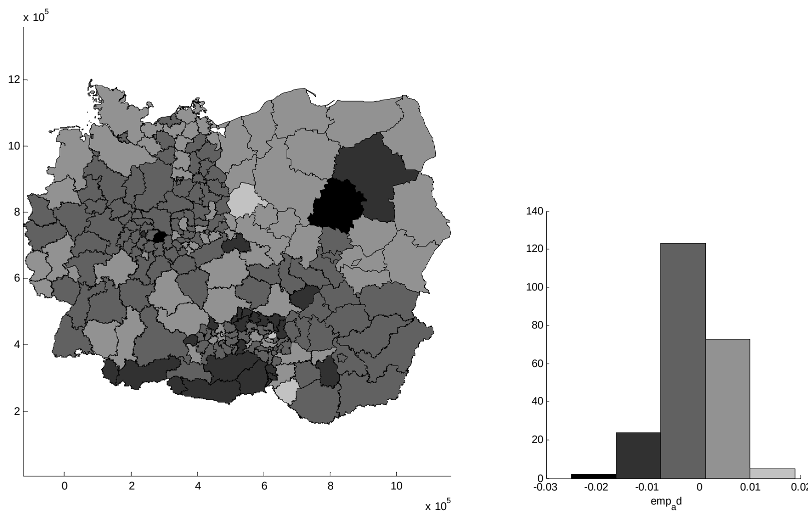
Surprisingly, the inverse rail TT weighted past EMPL growth rates are negative, also the coefficient of the road TT effects, although the sum of the effects of the growth rates on roads (short and long distance weighted) for the years 2000 and 1999 is Small negative (Lempl.gTT.road.99 + Lempl.giTT.road.00).

Table 3: EMPL Growth Model and Spatial Traffic Variables (BMA Estimates)

Bayesian Model Averaging	Estimates		
Dependent Variable: EMPL%,	Average GDP growth rate		(1995–2001)
R-squared	= 0.849		
Nobs= 227	Nvars = 23		
ndraws	= 25000		
nu,lam,phi	= (4., 0.25, 3)		
# models visited	589		
********************************	Posterior Estimates		
Variable	Coefficient	t-statistic	t-probability
const	0.020	1.6	0.11
Lempl.95	–0.010	–9.8	0.00
Lempl.gTT.road.99	–1.019	–2.8	0.00
Lempl.giTT.rail.00	–2.206	–4.4	0.00
Lempl.giTT.road.00	0.798	2.4	0.02
Lgdp.95	0.011	9.9	0.00
Lgdp.01.95	0.486	10.6	0.00
Lpop.00.95	0.481	8.1	0.00
TT.train.far	–0.000075/1000	–5.2	0.00
acc.all.bahn.dist.avg	–0.023	–5.5	0.00
potential.gdp.cap.95.rail	0.012	4.9	0.00
potential.empl.95.road	–0.007	–3.3	0.00
potential.gdp.00.95.rail	–0.298	–5.3	0.00
potential.gdp.cap.00.95.rail	0.310	8.7	0.00
potential.gdp.cap.00.95.road	–0.101	–3.6	0.00
potential.gdp.empl.00.95.rail	–0.247	–14.8	0.00
potential.gdp.empl.00.95.road	0.140	6.2	0.00
potential.all.gdp.00.95.rail	0.187	3.9	0.00
potential.all.gdp.cap.00.95.rail	–0.143	–5.2	0.00
d.aut	–0.001	–0.2	0.85
d.sk	0.024	9.6	0.00
d.hu	0.000	0.1	0.91
d.ger	–0.001	–0.4	0.70
d.pL	0.001	0.3	0.76

The, long distance weighted travel time for railways (TT.far.train) has a positive influence and might be interpreted as a good transportation proxy variable, while the effects of the 9 potential variables is quite mixed. The potential variables of GDP per capita (potential.gdp.cap.95.rail) have a positive effect, surprisingly many negative potential effects are found for rail TT potentials. But the highest positive potential effect is found for the change of the GDP per capita potentials for trains (potential.gdp.cap.00.95.rail: 0.31). This reflects some kind of complex interactions in the potential variables but also, that the rail and road TTs have different effects on the regional growth rates when combined with macro economic indicators.

Chart 3a: Scenarios Sensitivities of the Adjusted Model: The Differences between EMPL for 2020.



Legend: dark grey: negative growth, light grey: positive growth.

Summary of the sensitivity analysis for the adjusted model: 95 regions are negative, 25 have zero growth and 107 have positive employment effects in 2020.

The results of the employment growth sensitivity analysis are shown in chart 3 and table 4a for the scenario "free trains" (without major railway bottle necks) for EMPL% forecasts. We see negative employment growth effects only for the Hungarian and Polish regions, which were also in lowest ranks of GDP growth (Zala, Szczecinski, Nowosadecki, Podkarpackie) while the majority of regions exhibit a +/– zero effect. Positive effects can be seen again for Jena and for regions in Poland (Lodzkie) and Czech Republic (Zlinsky, Karlovarsky, Liberecky).[4]

[4] The best Austrian regions are Oberwart, Gmunden and Vöcklabruck.

From table 4b we see that the unadjusted EMPL growth differences are the lowest in Polish regions (Lodzkie, Mazowieckie, Centralny Slaski) and next to Jena (East Germany) there are, surprisingly, 5 regions from Austria. But also on the positive growth effect for Employment we find 6 regions of Austria, with Wels (Land), Vas and Jihocesky benefiting the most from better travelling times.

Table 4: Scenarios Sensitivities: The Top and Low EMPL Growth Differences for 2020

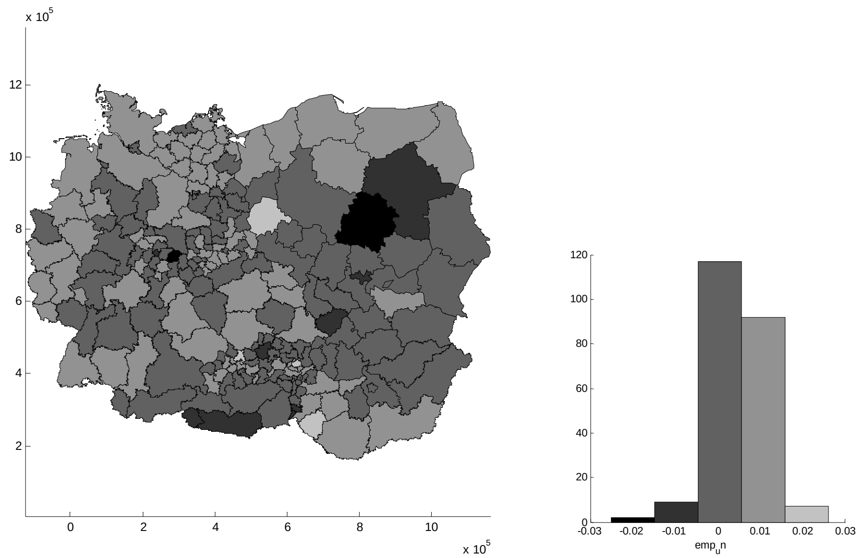
a) The adjusted model

Low 10		***Top 10***	
Jena	–0.025	Vas	0.008
Lodzkie	–0.025	Jihocesky	0.009
Jennersdorf	–0.014	Urfahr Umgeb.	0.009
Güssing	–0.014	St.Pölten Stadt	0.009
Osttirol	–0.013	Szczecinski	0.009
Zwettl	–0.013	Wien	0.013
Kärnten	–0.012	Zala	0.017
Oberwart	–0.012	Wels Stadt	0.018
Waidhofen a.d. Thaya	–0.011	Linz Stadt	0.018
Zlinsky	–0.011	Zielonogorski	0.019

b) The unadjusted model

Lodzkie	–0.025	Wels Land	0.015
Jena	–0.020	Vas	0.015
Mazowieckie	–0.008	Jihocesky	0.015
Jennersdorf	–0.006	Urfahr Umgeb.	0.017
Güssing	–0.006	St.Pölten Stadt	0.017
Osttirol	–0.006	Zielonogorski	0.019
Erfurt,	–0.006	Wien	0.021
Centralny Slaski	–0.005	Zala	0.024
Zwettl	–0.005	Wels Stadt	0.025
Kärnten	–0.005	Linz Stadt	0.026

Chart 3b: Scenario Sensitivities of the Unadjusted Model: The Differences between EMPL for 2020: Only 13% of the Regions Will Not Benefit from Improved Train Travel Times.



Summary of the sensitivity analysis for the unadjusted model: 29 regions are negative, 8 have zero growth and 190 have positive employment effects in the year 2020.

4. The Population Growth (POP%) Model with Spatial Traffic Interactions

The following table 5 summarizes the BMA estimation results.

From table 5 we see that the R2 is again quite high (0.77) but less than the previous 2 models. The intercept is –1% and not different from zero. No country fixed effects is significant. We conclude that population growth seems to follow a rather similar pattern in these 6 countries. The convergence coefficient of the log population level could not be significantly estimated and there are no level effects except the changes of potential variables. Interestingly, the GDP per capita and the GDP per worker potential variable enter the regression in pairs.

Table 5: POP Growth Model and Spatial Traffic Variables (BMA Estimates)

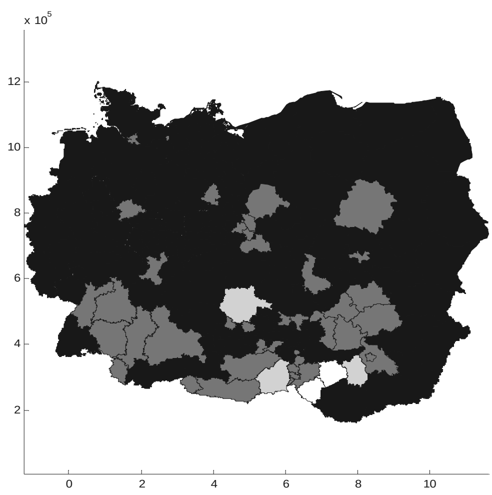
Bayesian Dependent Variable: POP%,	Model Average	Averaging Population	Estimates growth
R-squared = 0.7675			
Nobs = 227,	Nvars = 23,	Ndraws	= 25000
(nu,lam,phi) = (4., 0.25, 3)	# models	= 927	
**		Posterior Estimates	
Variable	Coefficient	t-statistic	t-probability
const	–0.01	–1.1	0.28
Lpop.gTT.rail.96	–74.65	–7.5	0.00
Lpop.gTT.rail.97	87.98	6.4	0.00
Lpop.gTT.rail.98	–110.03	–11.4	0.00
Lpop.gTT.road.97	–62.44	–6.1	0.00
Lpop.gTT.road.99	29.27	9.1	0.00
Lpop.giTT.rail.97	–8.79	–3.3	0.00
Lpop.giTT.rail.98	–13.86	–7.8	0.00
Lpop.giTT.road.96	–4.52	–4.9	0.00
Lpop.giTT.road.97	4.56	3.4	0.00
Lgdp.01.95	0.14	3.9	0.00
Lempl.01.95	0.20	4.7	0.00
TT.road.far	0.00	–4.4	0.00
TT.road.harm	0.00	2.8	0.01
potential.gdp.cap.00.95.rail	–0.15	–8.5	0.00
potential.gdp.cap.00.95.road	0.09	4.2	0.00
potential.gdp.empl.00.95.rail	0.11	6.8	0.00
potential.gdp.empl.00.95.road	–0.10	–5.3	0.00
potential.all.pop.00.95.rail	0.21	3.9	0.00
d.aut	0.00	1.1	0.26
d.sk	0.00	0.0	1.00
d.hu	0.00	–0.1	0.91
d.ger	0.00	–0.6	0.53
d.pl	0.00	–0.4	0.72

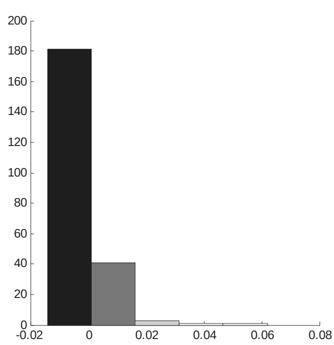
The productivity pair for road TT and train TT almost cancel (the sum of the coefficients of potential.gdp.empl.00.95.rail and potential.gdp.empl.00.95.road is

-.01), while for the GDP per capita pair, we find a negative combined effect for the changes (–0.06 for potential.gdp.cap.00.95.road and ~rail). That means that differences in potential growth in high growing regions are less favourable for population growth. Note that there is a fifth variable with a positive growth effect based on population potential differences, and it has the largest positive coefficient (potential.all.pop.00.95.rail: 0.21). This is an indication that regions benefit from a positive population growth feed back loop, based on population potentials and discounted by train travel times.

Note that dynamic time pattern for the TT weighted population growth rates is characterized by diversity and rather strong: 5 past TT weighted growth rate variables are far distance weighted (gTT), and 4 variables are short distance weighted (giTT). The effects of road based growth rates for the year 1996 and 1997 almost cancel (the sum is –4.52 + 4.56 = 0.04) while the combined effects of the short term effects from the year 1997 and 1998 are negative. Surprisingly, in the long run the combined effects of TT weighted past population growth rates are also negative (Lpop.gTT.road.97 + ~.99:–33) for road and –100 (sum of Lpop.gTT.rail.96, ~.97, ~.8) for train. This implies that regional train related growth is about 3 times as important than road related population growth. These estimates imply that the auto-projected population growth dynamics works negatively for all regions and will lead to depressed forecasts in the long run.

Chart 4a: Scenarios Sensitivities of the Adjusted Model: The Differences between POP Forecasts 2020: The Majority of Cells Will Have an Improvement up to 1%





Summary of the sensitivity analysis for the adjusted model: 140 regions have negative growth 23 zero growth, 64 positive growth rates.
The results of the population growth sensitivity analysis are shown in chart 4a and table 6a for the scenario 1: "free trains" (i.e. no major railway bottle necks) for POP% forecasts. We see negative population effects for a Hungarian region (Komarom-Esztergom) and Austrian city regions (Wels, Wien, Linz) and for Germany it is Jena (–1.1%). Some Austrian cities seem to develop a demographic trap: young people move out and leave old people behind.

The best population growth can be seen for Austrian regions (Jennersdorf, West-/Oststeiermark) and Hungarian regions (Fejer, Veszprem, Zala).

From table 6b we see the differences from the unadjusted model. Now Bratislava is on the loosing side for demographic influences, but also the cities Wels and Jena. Furthermore, we see further eastern regions with a negative demographic trend: 2 regions of Bohemia (Ustecky, Pardubicky) and 2 from Slovakia (Vychodne Slovensko, Zilinsky kraj), respectively. Under the top 10 best performing population growth regions we notice 5 regions from Austria (2 smaller ones from Burgenland, next to the "Lander" Kärnten and Vorarlberg) and some from Hungary (Veszprem, Zala) and Slovakia.

Table 6: Scenarios Sensitivities: The Top and Low POP Growth Differences

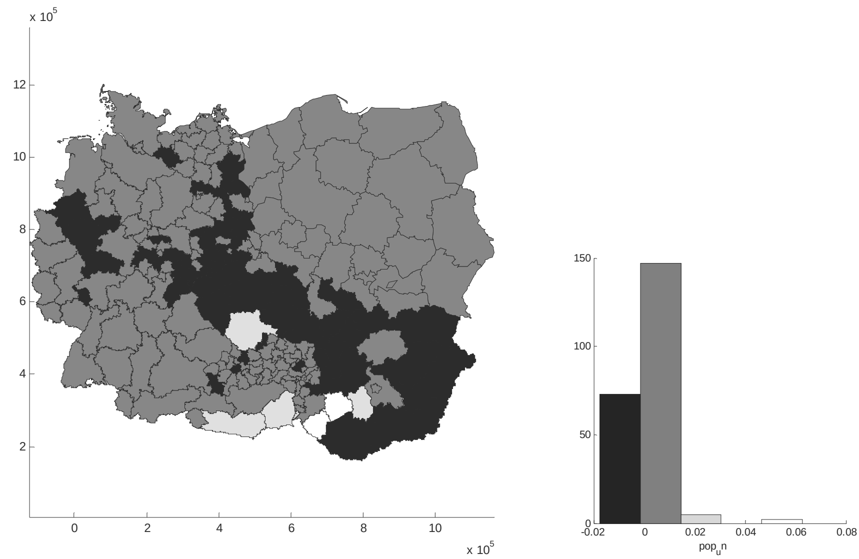
a) The adjusted model:

Komarom-Esztergom	–0.013	Jennersdorf	0.015
Wels Stadt	–0.012	West-/Oststeiermark	0.018
Wien	–0.011	Fejer	0.020
Linz Stadt	–0.011	Jihocesky	0.025
Jena	–0.011	Veszprem	0.047
Plauen (Stadt & Vogtland)	–0.010	Zala	0.063

b) The unadjusted model:

Low 10		***Top 10***	
Vychodne Slovensko	–0.017	Vas	0.012
Bratislavsky kraj	–0.015	Güssing	0.012
Komarom-Esztergom	–0.013	Vorarlberg	0.013
Ustecky	–0.012	Kärnten	0.015
Jena	–0.010	Jennersdorf	0.019
Plauen (Stadt & Vogtland)	–0.009	Fejer	0.020
Zilinsky kraj	–0.008	Jihocesky	0.021
Wels Stadt	–0.008	West-/Oststeiermark	0.022
Del-Dunantul	–0.007	Veszprem	0.047
Pardubicky	–0.007	Zala	0.063

Chart 4b: Scenario Sensitivities of the Unadjusted Model: The Differences between POP Forecasts 2020. The Number of Regions with Positive and Negative Changes is Almost Equal.



Summary of the sensitivity analysis for the unadjusted model: 97 regions have negative growth, 27 zero growth, and 103 positive growth differences.

Chart 4b shows that 97 regions (43%) have negative population growth rate differences due to improved TTs. This seems to be odd, since we would expect a larger proportion of regions. But it has to be taken into account (and as a sad fact?), that the demographic population trends in all regions of the 6 countries are completely negative (including cities but without migration) if the past trend of the 1990s is extrapolated. Thus, we have to view the results as a success, since now we predict 57% of the regions will have positive population growth if the improvements in TT will be implemented. Clearly, region growth will become more competitive in the next decades since the population is shrinking in central Europe and migration trends are difficult to predict in the long run, as we have seen from the migration wave around 1990, i.e. the fall of the Iron Curtain.

Table 7: Summary of TT Scenario 2

a) adjusted model

	negative	zero	positive
GDP	0.38	0.10	0.52
EMPL	0.42	0.11	0.47
POP	0.62	0.10	0.28

b) unadjusted model

	negative	zero	positive
GDP	0.96	0.01	0.03
EMPL	0.13	0.04	0.84
POP	0.43	0.12	0.45

From table 7 we see that in the adjusted model we can expect positive GDP effects for more than 50 % of the regions to profit from train TT. Positive employment effects can be expected a little bit less (i.e. 47 %), and the lowest train TT effects can be expected for population growth: just every 4th region or 28 % of the regions will benefit.

Clearly, our population growth forecasting does not follow standard demographic projection methods which are based on yearly age groups and different fertility and mortality assumptions. Surprisingly, our long-term forecast are very similar, as we can see from appendix B, where we have compared the forecasts from the ÖROK (which actually was made by Statistics Austria, the central statistical office of Austria) and our level forecast, based on iterative application of the panel growth rate forecasts. As we see differences are very small, the largest being for a small region in northern Austria (Gmünd) with 0.5%. Other minor differences can be found for the suburbs of Vienna, where the largest absolute increase in population is expected. Since no reliable migration data could have been obtained for the 6 countries and the period 1995–2001, we hope to find a smaller model in future that can incorporate (reliable) migration variables as well[5].

4. Conclusions

We have shown in this paper that the regional growth rates of GDP, Employment and population can be explained to a large degree by traffic dependent spatial or time series variables. The dynamic panel model was estimated by BMA and allows sensible long-term predictions of these regional target variables. Also, a TT and

[5] Currently, reliable and comparable migration (balance) data were only available for the year 2001, but the effects were not significant.

traffic related sensitivity analysis was discussed: We see that the traffic scenario "free train", i.e. a removal of all bottle-necks of the current year 2000 in rail network of central Europe, will bring on average more regions positive growth. Some regions could see slower growth if the new accessibilities will change the focus of economic growth.

The growth scenario will change slightly if we impose the restriction that the future growth rates will take place on the expense of regional reallocations in each of the 6 countries. These growth rates differences will be in the range of +/–2% of the GDP level in the year 2020. These results were obtained by a sensitivity analysis and is valid for both, the adjusted (i.e. country restricted regional growth) and unadjusted (i.e. unrestricted regional growth) model. It seems that accessibilities by TT improvements will best benefit employment growth in a few regions across the 6 countries. Also, about 50% of the regions will be positively influenced by TT improvements for GDP. An important sensitivity result concerns the population growth: According to our traffic related model, 43% region can not reverse the negative demographic trend in the future and will shrink (ceteris paribus, i.e. holding other influence factors fixed). But it should be kept in mind that the GDP and other growth rates can be highly volatile: Our (sensitivity) results are dominated short run time dynamics and eventually TT improvements will have different effects in the long run if other influencing factors are considered.

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Appendix A: List of Variable Abbreviations

Lgdp.1995	Logarithm real GDP
Lgdp.gTT.rail.96	average GDP growth rates 1996, weighted by rail TT
Lgdp.gTT.rail.97	average GDP growth rates 1997, weighted by rail TT
Lgdp.gTT.rail.98	average GDP growth rates 1998, weighted by rail TT
Lgdp.gTT.rail.99	average GDP growth rates 1999, weighted by rail TT
Lgdp.gTT.rail.00	average GDP growth rates 2000, weighted by rail TT
Lgdp.gTT.road.96	average GDP growth rates 1996, weighted by road TT
Lgdp.gTT.road.97	-”- 1997
Lgdp.gTT.road.98	-”- 1998
Lgdp.gTT.road.99	-”- 1999
Lgdp.gTT.road.00	-”- 2000
Lgdp.giTT.rail.96	average GDP growth rates 1996, weighted by inverse rail TT
Lgdp.giTT.rail.97	average GDP growth rates 1997, weighted by inverse rail TT
Lgdp.giTT.rail.98	average GDP growth rates 1998, weighted by inverse rail TT
Lgdp.giTT.rail.99	average GDP growth rates 1999, weighted by inverse rail TT
Lgdp.giTT.rail.00	average GDP growth rates 2000, weighted by inverse rail TT
Lgdp.giTT.road.96	average GDP growth rates 2000, weighted by inverse road TT
Lgdp.giTT.road.97	-”- 1997
Lgdp.giTT.road.98	-”- 1998
Lgdp.giTT.road.99	-”- 1999
Lgdp.giTT.road.00	-”- 2000
Lempl.95	Logarithm of employment 1995
Lpop.95	Logarithm of population 1995
Lpop.dichte.95	Logarithm of population density 1995
Lempl.00.95	% changes of employment 1995-2000
Lpop.00.95	% changes of population 1995-2000
youth.dep.ratio	percentage of 0-20 years old in the population
old.dep.ratio	percentage of 60+ years old in the population
nodes.per.highway.km	highway access points per highway km
highway.per.km2	highway density in a region
Roads.per.km2	road density in a region
Railstation.per.km	Rail station density per rail net km
Railnet.per.km2	railway density in a region
TT.train.ave	average train TT
TT.train.far	average train TT, weighted by distance
TT.train.near	average train TT, weighted by inverse distance
TT.train.harm	harmonic average train TT
TT.train.speed	average speed for rail ways
TT.road.ave	average road TT
TT.road.far	average road TT, weighted by distance
TT.road.near	average road TT, weighted by inverse distance
TT.road.harm	harmonic average road TT
TT.road.speed	average speed on road
potential.gdp.95.rail	within country potential index based on GDP and rail TT 1995
potential.gdp.95.road	within country potential index based on GDP and road TT 1995
potential.gdp.cap.95.rail	within country potential based on GDP per capita and rail TT 1995
potential.gdp.cap.95.road	within country potential based on GDP per capita. and road TT 1995
potential.pop.95.rail	within country potential based on population and rail TT 1995

potential.pop.95.road	within country potential based on population and road TT 1995
potential.empl.95.rail	within country potential based on employment and rail TT 1995
potential.empl.95.road	within country potential based on employment and road TT 1995
potential.gdp.empl.95.rail	within country potential based on productivity and rail TT 1995
potential.gdp.empl.95.road	within country potential based on productivity and road TT 1995
potential.gdp.00.95.rail	% change of potential index based on GDP and rail TT 1995-2000
potential.gdp.00.95.road	% change of potential index based on GDP and road TT 1995-2000
potential.gdp.cap.00.95.rail	% change of potential index based on GDP_pc and rail TT 1995-2000
potential.gdp.cap.00.95.road	% change of potential index based on GDP_pc and road TT 1995-2000
potential.pop.00.95.rail	% change of potent. index based on population and rail TT 1995-2000
potential.pop.00.95.road	% change of potent. index based on population and road TT 1995-2000
potential.empl.00.95.rail	% change of pot. index based on employment and rail TT 1995-2000
potential.empl.00.95.road	% change of pot. index based on employment and road TT 1995-2000
potential.gdp.empl.00.95.rail	% change of pot. index based on productivity and rail TT 1995-2000
potential.gdp.empl.00.95.road	% change of pot. index based on productivity and road TT 1995-2000
potential.all.gdp.95.rail	-“- as above but for all 6 countries (227 regions)
potential.all.gdp.95.road	-“- as above
potential.all.gdp.cap.95.rail	-“- as above
potential.all.gdp.cap.95.road	-“- as above
potential.all.pop.95.rail	-“- as above
potential.all.pop.95.road	-“- as above
potential.all.empl.95.rail	-“- as above
potential.all.empl.95.road	-“- as above
potential.all.gdp.empl.95.rail	-“- as above
potential.all.gdp.empl.95.road	-“- as above
potential.all.gdp.00.95.rail	-“- as above
potential.all.gdp.00.95.road	-“- as above
potential.all.gdp.cap.00.95.rail	-“- as above
potential.all.gdp.cap.00.95.road	-“- as above
potential.all.pop.00.95.rail	-“- as above
potential.all.pop.00.95.road	-“- as above
potential.all.empl.00.95.rail	-“- as above
potential.all.empl.00.95.road	-“- as above
potential.all.gdp.empl.00.95.rail	-“- as above
potential.all.gdp.empl.00.95.road	-“- as above
d.aut, d.sk, d.hu, d.ge, d.cr, d.pl.	Dummy variables for countries

Appendix B: Comparison of the ÖROK Population Forecast and the Panel Forecast

ÖROK forecast	2001	2021		total population 2001–2031	panel-forecast	relative difference
Amstetten, Waidhofen a. d. Ybbs	121,156	120,376	108.9	Amstetten	120.5	0.1%
Baden	126,807	140,973		Baden	140.4	–0.4%
Braunau am Inn	94,859	96,844		Braunau	96.8	0.0%
Bruck a. d. Leitha	39,942	42,465		Bruck a.d. Leitha	42.4	–0.3%
Eferding	30,559	31,018		Eferding	31.0	–0.1%
Eisenstadt (St+U), Rust	51,886	54,644	11.9	Eisenstadt (Stadt)	54.5	–0.3%

Freistadt	63,948	65,160	Freistadt	65.2	0.0%
Gänserndorf	88,338	100,580	Gänserndorf	100.1	–0.5%
Gmünd	39,989	36,413	Gmünd	36.6	0.5% *)max
Gmunden	99,298	100,384	Gmunden	100.4	0.0%
Grieskirchen	61,901	63,149	Grieskirchen	63.1	0.0%
Güssing	26,902	25,699	Güssing	25.8	0.3%
Hollabrunn	49,906	52,695	Hollabrunn	52.6	–0.3%
Horn	32,252	31,270	Horn	31.3	0.2%
Jennersdorf	17,863	17,633	Jennersdorf	17.7	0.1%
Kirchdorf a. d. Krems	55,097	56,069	Kirchdorf	56.1	0.0%
Korneuburg	67,917	78,495	Korneuburg	78.0	–0.6%
Krems (Land)	54,267	55,081	Krems (Land)	55.1	0.0%
Krems a.D. (Stadt)	23,669	25,053	Krems an der Donau	25.0	–0.2%
Lilienfeld	26,989	27,221	Lilienfeld	27.2	0.0%
Linz(Stadt)	184,100	183,834	Linz Stadt	183.9	0.0%
Linz–Land	129,220	144,024	Linz Land	143.6	–0.3%
Mattersburg	37,400	40,163	Mattersburg	40.1	–0.2%
Melk	75,358	76,345	Melk	76.4	0.0%
Mistelbach	72,511	75,742	Mistelbach	75.6	–0.2%
Mödling	106,411	117,230	Mödling	116.8	–0.4%
Neunkirchen	85,675	85,323	Neunkirchen	85.4	0.1%
Neusiedl am See	51,659	52,785	Neusiedl	52.7	–0.1%
Oberpullendorf	37,840	37,356	Oberpullendorf	37.4	0.1%
Oberwart	53,276	51,168	Oberwart	51.3	0.2%
Perg	63,980	69,596	Perg	69.4	–0.3%
Ried im Innkreis	58,132	60,720	Ried	60.7	–0.1%
Rohrbach	57,699	57,694	Rohrbach	57.7	0.1%
Sankt Pölten (Land)	93,166	98,794	St.Pölten (Land)	98.6	–0.2%
Sankt Pölten (Stadt)	49,111	51,080	St.Pölten Stadt	51.0	–0.1%
Schärding	56,851	59,028	Schärding	59.0	–0.1%
Scheibbs	41,343	40,089	Scheibbs	40.2	0.2%
Steyr(Stadt)	39,443	39,988	Steyr Stadt	40.0	0.0%
Steyr-Land	57,526	59,292	Steyr Land	59.3	–0.1%
Tulln	64,422	73,858	Tulln	73.5	–0.5%
Urfahr-Umgebung	77,856	88,359	Urfahr Umgeb.	88.0	–0.4%
Vöcklabruck	126,523	130,388	Vöcklabruck	130.3	0.0%

Waidhofen a. d. Thaya	28,144	27,115	Waidhofen a.d. Thaya	27.2	0.2%
Wels(Stadt)	56,628	61,389	Wels Stadt	61.3	–0.2%
Wels-Land	62,986	68,663	Wels Land	68.5	–0.3%
Wien	1,550,679	1,656,554	Wien	1653.3	–0.2%
Wien Umgebung	102,025	118,264	Wien Umgebung	117.6	–0.0054
Wr Neustadt (Stadt)	37,677	40,771	Wiener Neustadt	40.7	–0.0024
Wiener Neustadt(Land)	71,850	79,842	Wiener Neustadt(Land)	79.5	–0.0038
Zwettl	45,587	41,720	Zwettl	41.9	0.0049