Regional Growth in Central Europe: Long-term Effects of Population and Traffic Structure

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Abstract

In a simple growth model we explore the current and future growth effects of the regional population structure. Regional GDP growth in 227 regions within six countries in central Europe is explored as how they depend on the young and old dependency ratio. The young dependency ratio (YDR) is defined as ratio of the less than 20 years old and the old dependency ratio (ODR) as the more than 60 years old divided by the total population. We found a medium sized negative correlation of these ratios on regional growth and the long-term forecasts for the year 2020 are for most regions rather negative if only the population structure is considered. Similar scenarios can be also obtained for employment and population growth. The long-term forecasts improve if traffic accessibilities and dynamic interactions are introduced into the model.

Keywords

JEL Classification

Contents

1. Introduction

Age structure and growth have become a highly disputed topic for growth scenarios of countries around the world. Some papers have explored the impact of the age structure on economic growth (see e.g. Brunow and Hirte 2005). But only a few econometric results are available on a regional level with panel data. This short note explores the effect of regional growth in six European countries for the period 1995 to 2001: Austria, Hungary, Slovakia, Poland, Germany and the Czech Republic.

Figure 1.1 shows the young dependency ratio (YDR) over the 227 regions and we see a large dependency ratio along the eastern border of Poland and Slovakia. But surprisingly, also some smaller cells of upper Austria, East Tyrol, Vorarlberg and Salzburg have a dependency ratio of above 25%. The contour plot is based on the coordinates of the region centres and interpolates the YDR variable. Small values of the young dependency ratio can be seen for irregularly shaped regions in Saxony and a small stretch near the Netherlands border.

Figure 1.2 shows the old dependency ratio and clearly the cells in eastern Germany, especially in Saxony, exhibit the largest old dependency ratio, but also in Western Germany most cells show high values. In Austria we see the northern regions of lower Austria, Burgenland and Upper Styria to have high old dependency ratios. The regions in Northwest Poland have the lowest ODR ratios of six the countries. While Poland can be divided into four regions if we look at the map of the old dependency ratios, many of the regions in the Czech Republic and Hungary have also "old dependency" of about 20%.
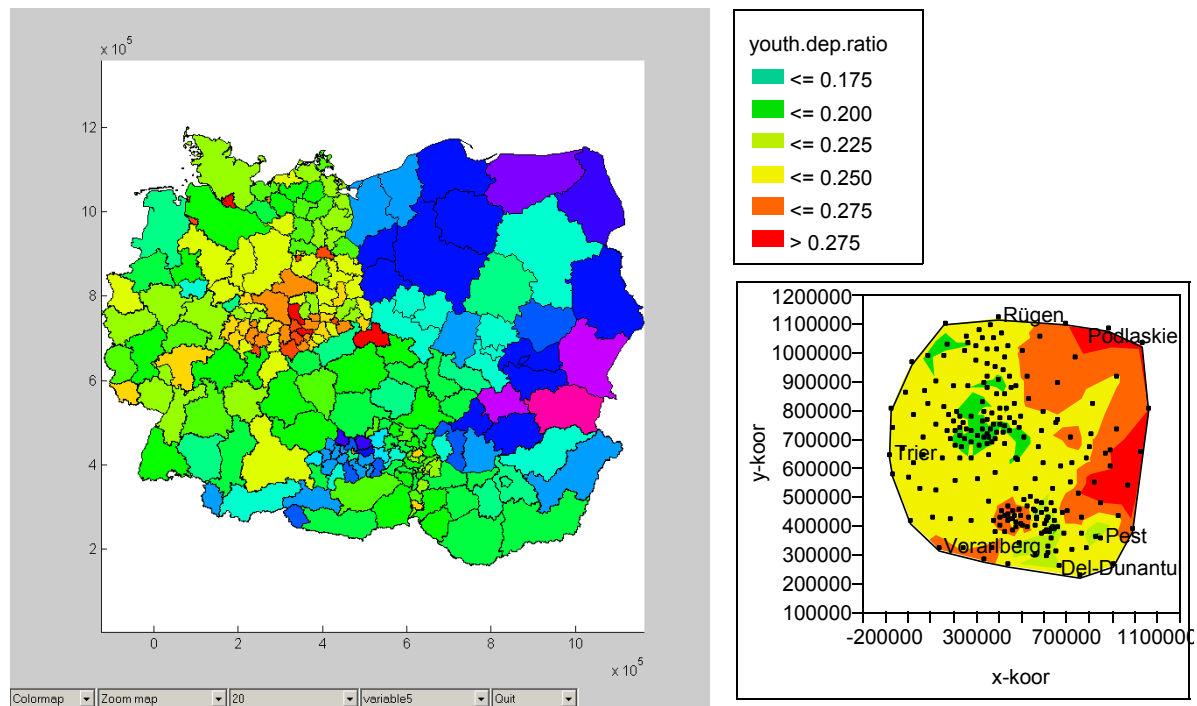
Figure 1.1: Young dependency ratio YDR: (0-20 years / Pop.) and contour plot
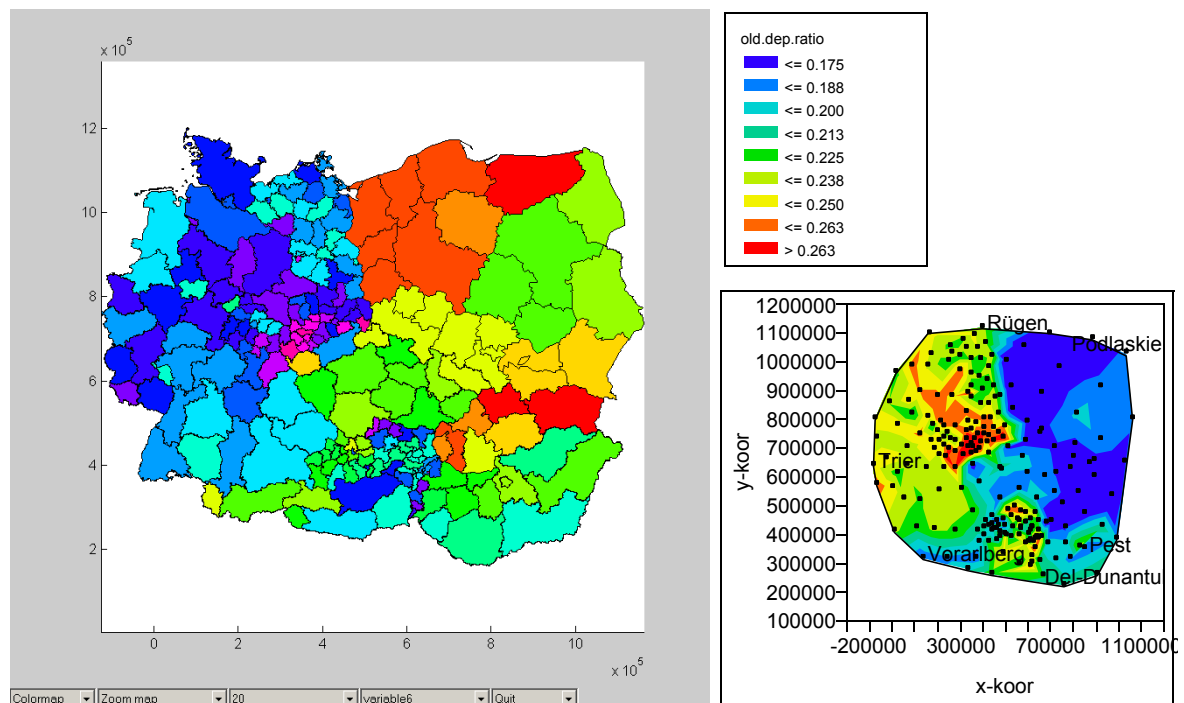
Figure 1.2: Old dependency ratio ODR: (60+ / Pop.) and contour plot

2. GDP growth and population structure

In the following section we explore the relationship between regional GDP growth and the young and old dependency ratios.

Table 2.1:   Correlation matrix of GDP growth and the dependency ratios YDR and ODR (p-values in parenthesis)

(p-val)	GDP%	YDR	ODR
GDP%	1	0.39	-0.41
YDR	(0.0)	1	-0.82
ODR	(0.0)	(0.0)	1

Note: all correlations are significantly different from zero.
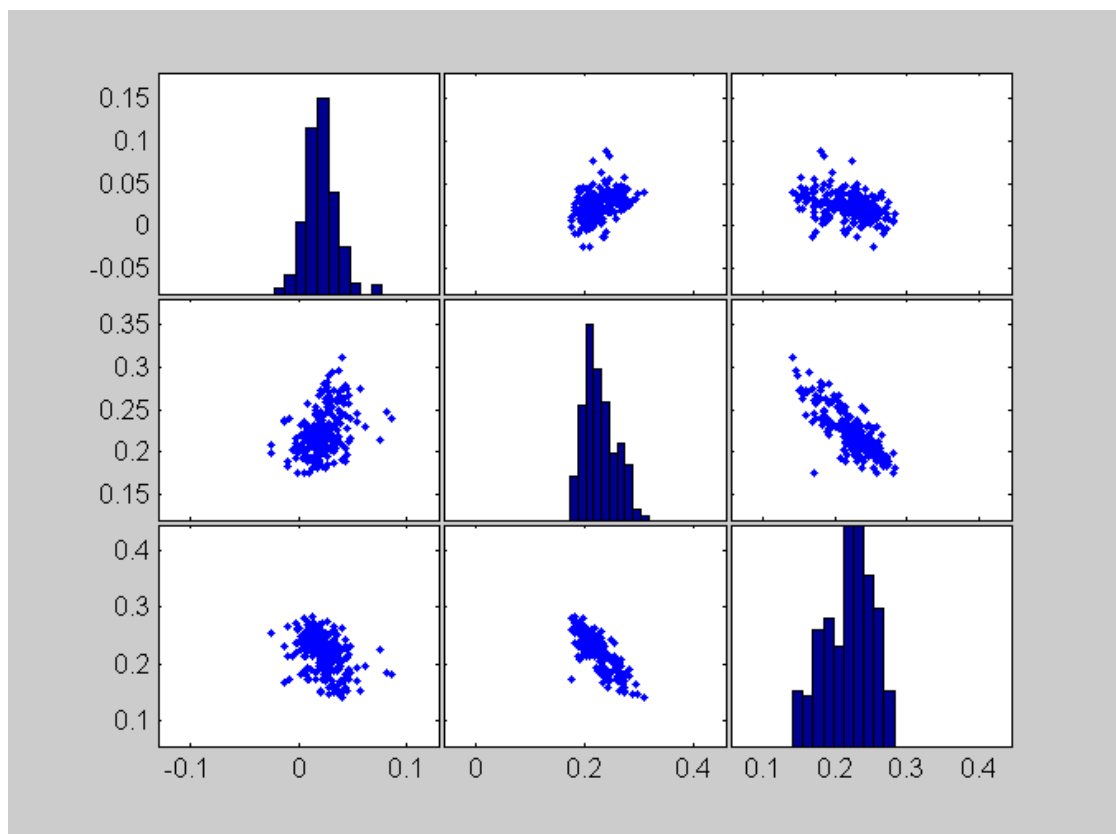
Figure 2.1: Scatterplot-matrix of GDP growth and the dependency ratios YDR and ODR

From Figure 2.1 and the correlation table 2.1 we see that the correlation coefficient between GDP growth and the young dependency ratio is positive while the correlation coefficient between GDP growth and the old dependency ratio is negative. As a consequence both dependency ratios (ODR and YDR) are negatively correlated. This can be also seen from the scatter plot matrix that summarizes the 227 regions in central Europe.

2.1 Long Term Forecast Implications

For the year 2020 long-term population growth projections are available from the statistical offices in the six countries. From these forecasts for 2020 we computed the future young and old dependency ratio and used them for a conditional forecast for the GDP growth in the year 2020. In order to compare the impact of the population structure on GDP growth we also computed the difference between the past estimates and the estimated forecasts.

First, in Table 2.2, we computed the simple regression models to explore the effects of old and young dependency ratios on the GDP growth rate, and in table 2.3 we computed the fixed effect regression model, i.e. we substituted the intercept by the six dummy variables for the six countries.

In Figure 2.3 we plotted a map of the fitted values of the fixed effect models for 2000 and in Figure 2.4 the forecasts of the fixed effect model for the regressor data of 2020. These fitted values are the point forecast for GDP growth for the year 2020, given the (official) forecasts of young and old dependency ratios for 2020, but the coefficients of the model are based on the data observation from 1995 to 2001.

Table 2.2:   Regression estimates for the simple model

OLS	coeff.	Conf-Intervals.	
	b	b_lower	b_upper
intercept	0.030	-0.017	0.076
young DR	0.096	-0.025	0.218
old DR	-0.130	-0.230	-0.031
	R^2	F-Stat	p-value
	0.175	23.68	0

Table 2.3: Regression estimates for the fixed effect model and population structure (PS)

OLS	coeff.	Conf- Intervals	
	b	b_lower	b_upper
d_aut	0.091	0.042	0.140
d_sk	0.099	0.052	0.147
d_hu	0.090	0.042	0.138
d_ger	0.080	0.031	0.128
d_p	0.093	0.045	0.140
d_cz	0.065	0.019	0.110
young	-0.099	-0.220	0.023
old	-0.182	-0.299	-0.065
	R^2	F-Stat	p-value
	0.376	18.88	0

For interpretation purposes we refer to the measurement scale of dependency ratios, i.e. the values from 0 to 1 as percentages or 100 basis points (bp). From the simple model we see that the increase of 10 basis points in the YDR increase the GDP growth by about 1%-point. The effect of 10 bp of the ODR is negative and larger: about -1.2%-points. Note that in the fixed effect model both effects are negative and ODR coefficient is double the size. 10bp difference in the DR will decrease GDP growth of about 1%-point for YDR and -1.8%-points for ODR. If there were no old or young people in the population we see from the fixed effects that average growth could lie between 6.5% pa (CZ) and 9.9% (SK):
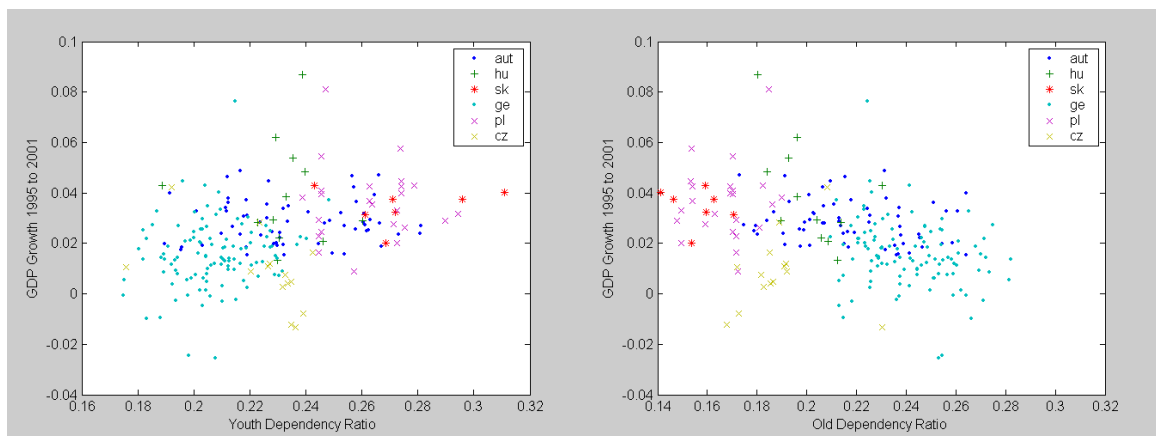
Figure 2.2: Scattergrams of GDP% with YDR and ODR: Simpson paradox visualized

The regression estimates in Table 2.2 and Table 2.3 show that the so-called Simpson effect is present in the data. While in the simple regression model the coefficient of the young dependency ratio is positive, it is negative for the fixed effect model. This means if we condition the regression of GDP growth on the six countries, we observed a negative correlation between growth and young dependency ratio, while for the simple model we see a positive slope, implying that the growth rates of the six countries were rather widely and heterogeneously distributed.

Note that Simpson Paradox can best explain the reversal of the sign of the YDR coefficient. The youth dependency ratios are increasing with faster growing countries, as can be seen from Figure 2.2, while the connection of GDP growth and YDR within countries is mainly negative. This negative slope can be estimated if we control for the within country relationships by the fixed effects.
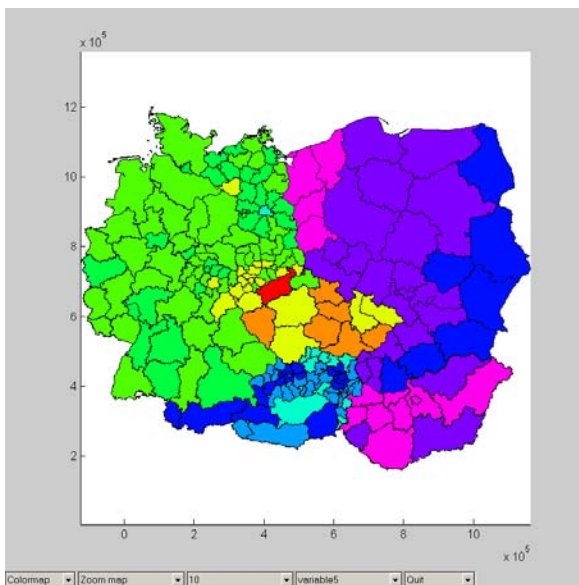
Figure 2.3: Estimated GDP% (yhat) for 2000   **Figure 2.4: Forecasted GDP% for 2020**
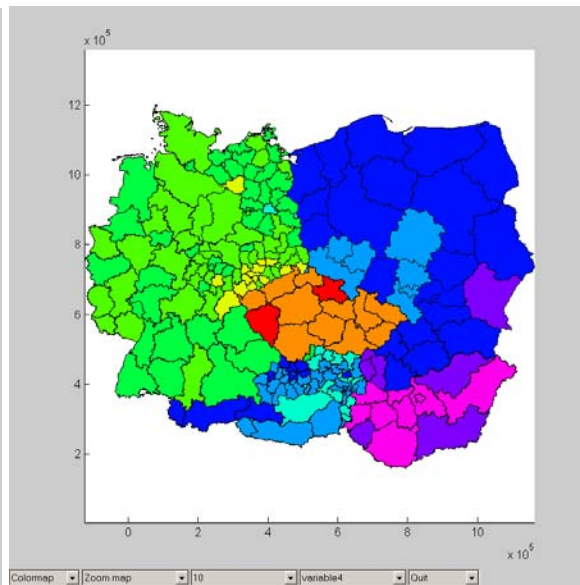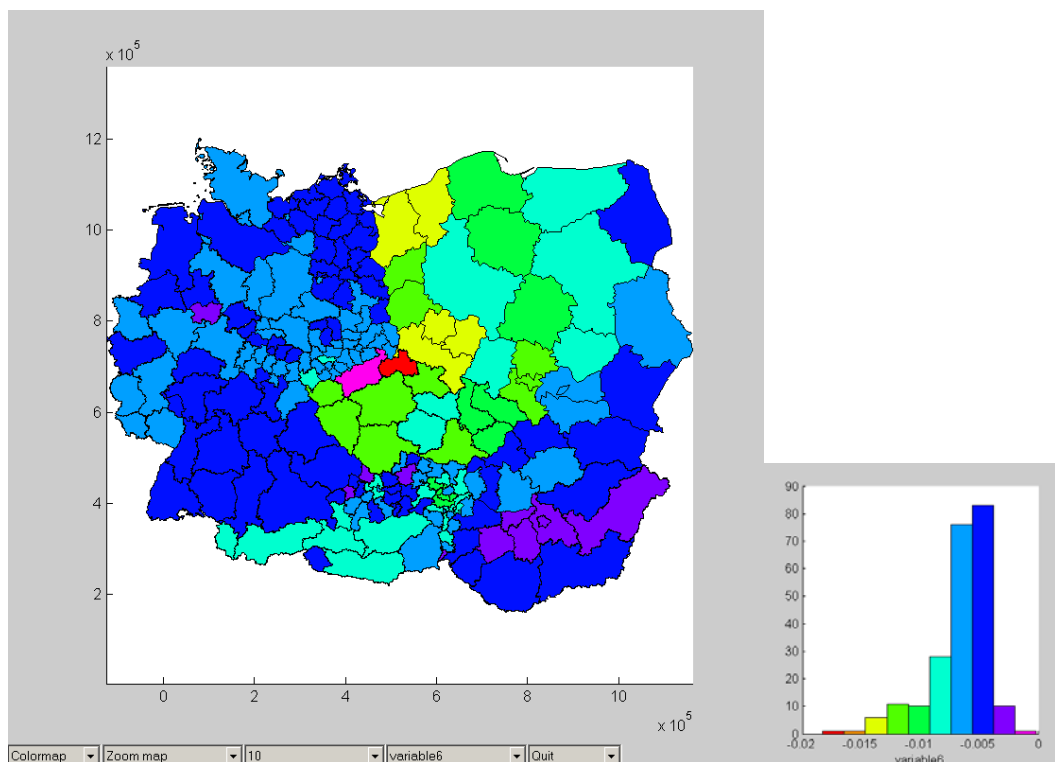
Figure 2.5: Difference of forecasts (yhat 2020 - yhat 2000) due to population structure

Note that these country dummies double the size of the R^2; nevertheless the overall strength of the relationship is small and it is of no surprise if this effect on population structure cannot be found in complex (dynamic) regression models of GDP growth.

Figure 2.3 shows that the lowest GDP growth is estimated by the fixed effect (and PS) model for the Czech regions. This is because the Czech Republic experienced two recession years (1997 and 1998), which leads to a depressed average growth rate. The highest GDP% rates can be found in Hungary, notable the Budapest corridor and the regions along the Polish western border. The second highest growth rates are found in PL and SK, and in Austria along the "Westbahn" (Vienna-Bregenz) corridor.

Figure 2.4 maps the predictions from the fixed effect model for the year 2020. The highest regional growth rates can be seen for HU, the second highest for PL, SK and Austria. CZ comes last.

The difference of fitted values (yhat 2020 - yhat 2000) in Figure 2.5 shows that the values for all regions are negative, which is due to increasing dependency ratios. We see that the maximum negative effect on yearly GDP growth is observed for northern Bohemia. Also around Sczeczin and Wroclaw (Silesia in Poland) the regions suffer from the predicted Old dependency ratio in 2020. Note that whole of Germany (including Eastern Germany), Hungary and Slovakia will only be slightly affected, but all regions in the Czech Republic will have a growth disadvantage. Similar growth impediment can be seen for most regions in Poland, except for the eastern border regions. Surprisingly the alpine regions in Austria except East Tyrol will loose growth potentials due to adverse population structure, which should be explored in more detail.

2.2 Long Term Forecasts and Traffic Infrastructure (TI)

In the following we add to the model traffic infrastructure variables.

Table 2.4: Regression estimates for population structure (PS) and traffic infrastructure (TI)

Ordinary Least-squares Estimates			
Dependent Variable	=	Avg GDP growth 1995 – 2001	
R^2	=	0.3942	
Adj. R^2	=	0.3603	
σ^2	=	0.0002	
Durbin-Watson	=	1.7493	
Nobs, Nvars	=	227	13
Variable	Coeff.	t-statistic	t-probability
d_aut	0.1156	3.8449	0.0002
d_sk	0.1206	4.1903	4E-05
d_hu	0.1149	3.9115	0.0001
d_ger	0.1007	3.4184	0.0008
d_p	0.1157	4.0284	8E-05
d_cz	0.0867	3.1458	0.0019
youth dep. ratio	-0.172	-2.294	0.0228
old dep. ratio	-0.195	-3.019	0.0028
nodes per highway-km	0.0053	0.4413	0.6594
highway per km^2	-0.036	-0.811	0.4183
Roads per km^2	0.0229	0.9613	0.3375
Railstation per km	-0.088	-1.652	0.1
Railnet per km^2	-0.037	-1.383	0.1682

Legend:

nodes per highway-km : Number of highway entrances per highway-km

highway per km^2: Autobahn Km per region-area

Roads per km^2: Total Road length per region-area

Railstation per km: Number of railway stations per railway-net km

Railnet per km^2: railway-net per region-area

From Figure 2.6a we see the differences of fitted GDP% rates between the fixed effect model and the traffic infrastructure (TI) augmented regression model. Traffic induced growth is generally scattered around city regions while the strongest positive differences have been observed for structural weak regions in Northern CZ (Liberec), Upper Styria and south Burgenland (both AT).

Figure 2.6b shows the difference of growth forecasts for the year 2020. Again, the best forecasts can be seen for regions in Poland and Austria while only a few regions will not benefit: These are some Polish regions (including Warsaw) and Alpine regions in Austria.
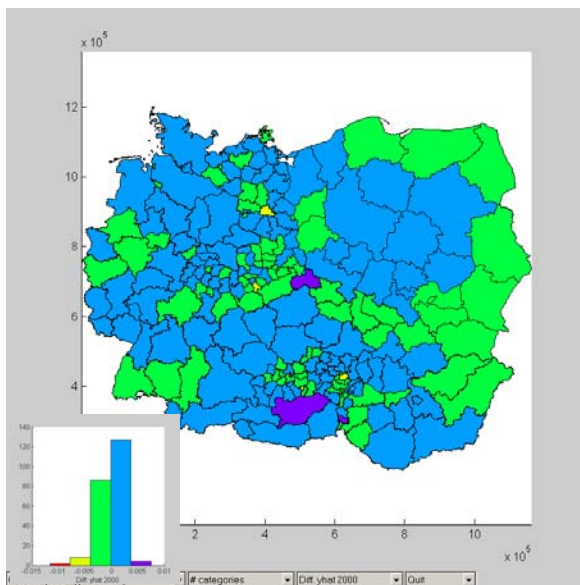
Figure 2.6a: Difference of average growth estimates (yhat 2000(PS&TI) – yhat 2000 (PS)) due to traffic infrastructure
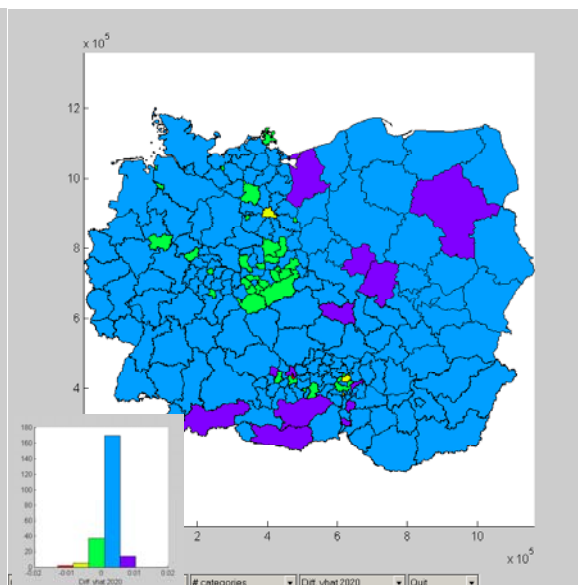
Figure 2.6b: Difference of growth forecasts (yhat 2020(PS&TI) – yhat 2020(PS)) due to traffic infrastructure

2.3 Long Term Forecasts and Dynamic Structure (DS)

Table 2.5: Regression estimates for population structure (PS), traffic infrastructure (TI) and time dynamics (DYN)

Ordinary Least-squares Estimates			
Dependent Variable	=	Avg LOG GDP	
R^2	=	0.9305	
Adj. R^2	=	0.9248	
σ^2	=	0	
Durbin-Watson	=	2.2554	
Nobs, Nvars	=	227	18
Variable	Coefficient	t-statistic	p-value
Lgdp_95_96	0.171	15.7	0.00
Lgdp_96_97	0.163	13.2	0.00
Lgdp_97_98	0.165	12.2	0.00
Lgdp_98_99	0.177	15.9	0.00
Lgdp_99_00	0.163	13.2	0.00
Youth dep. ratio	0.001	0.0	0.96
old dep. ratio	0.007	0.3	0.78
nodes per highway-km	0.004	1.0	0.33
highway per km^2	0.020	1.3	0.20
Roads per km^2	-0.001	-0.1	0.92
Railstation per km	0.009	0.5	0.63
Railnet per km^2	-0.011	-1.2	0.23
d_aut	-0.001	-0.1	0.93
d_sk	0.004	0.4	0.71
d_hu	0.004	0.3	0.73
d_ger	-0.001	-0.1	0.90
d_p	-0.002	-0.2	0.87
d_cz	0.002	0.2	0.85
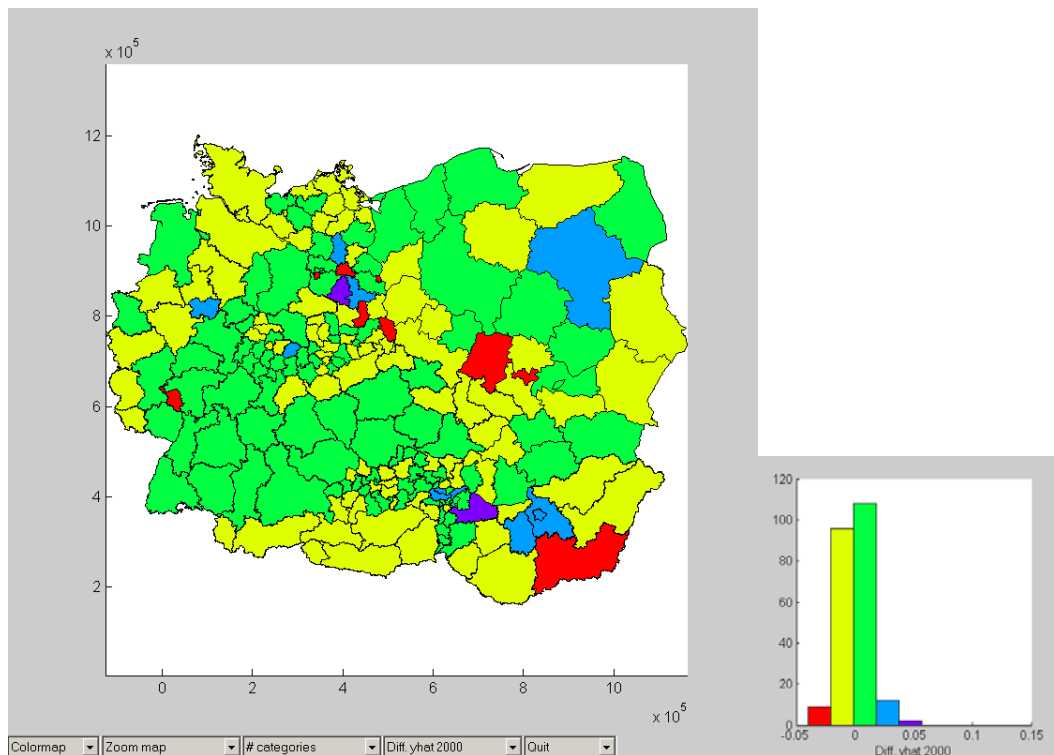
Figure 2.7a: **Difference of fitted average growth (yhat 2000(PS & TI & DYN) – yhat 2000(PS & TI)) due to time dynamics**
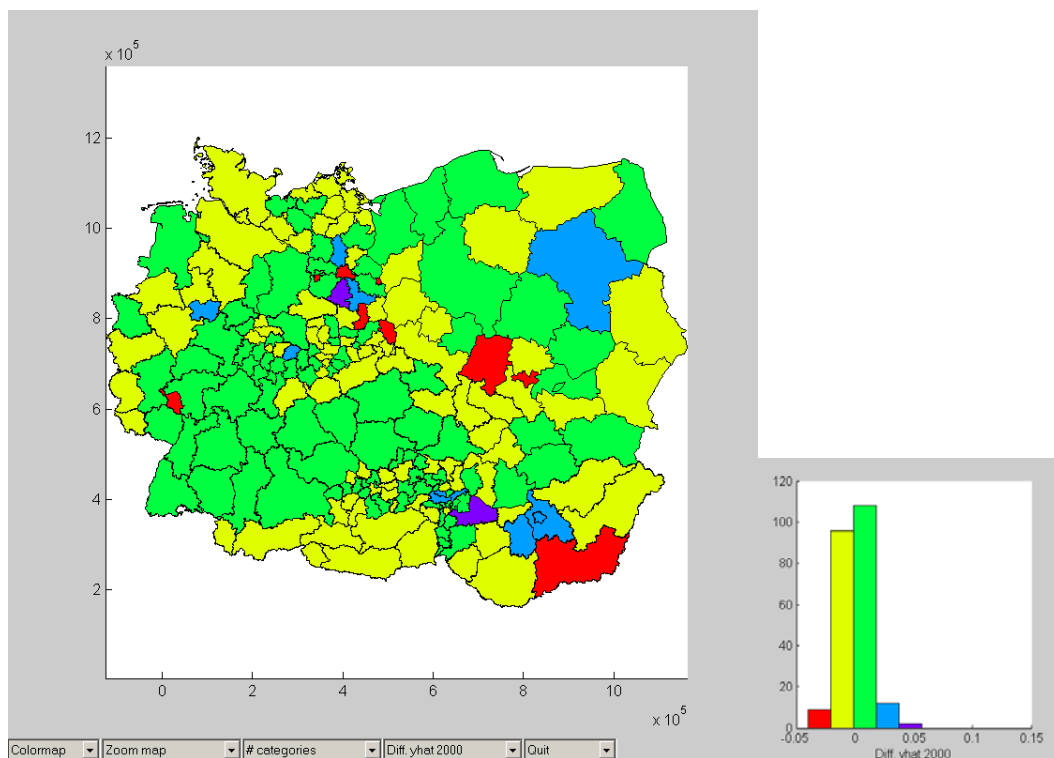
Figure 2.7b: **Difference of growth forecasts (yhat 2020(PS & TI & DYN) – yhat 2020(PS & TI)) due to time dynamics**

Figure 2.7a and Figure 2.7b shows the differences of fitted GDP% rates between the traffic infrastructure regression model and the time dynamic augmented model. Interestingly, the dynamic effects are scattered around the whole six countries. For example, Budapest and Warsaw will profit from a dynamic development if it is similar as in the past. This shows that the dynamic component in the model is rather regional heterogeneous.

Table 2.6: R^2 Increase by model nesting for GDP %

	R^2	Diff. R^2
PS	0.1745	
6D (country dummies)	0.3487	0.17
6D + PS (population structure)	0.3763	0.03
6D + PS + TI (Traffic infrastructure)	0.3942	0.02
6D + PS + TI + Dynamics (lagged dep. variables)	0.9269	0.53

Comparing the R^2 of nested models in Table 2.6 yield the following insights: 17% of the R^2 is explained by the dummy variables. Population structure and traffic infrastructure is also week, between 2 and 3%. Only the time domain explains more than ½ for the model fit: 53%.

	R^2	BMA Diff. R^2
PS	0.1745	
6D (country dummies)	0.3487	0.17
6D + PS (population structure)	0.3763	0.03
6D + PS + TI (Traffic infrastructure)	0.3942	0.02
6D + PS + TI + Dynamics (lagged dep. variables)	0.9269	0.53

3. Employment growth and population structure

In the following section we explore the relationship between regional employment growth and the young and old dependency ratios.

Table 3.1: Correlation matrix of EMPL growth and dependency ratios (p-values in parenthesis)

(p-val)	EMPL%	YDR	ODR
EMPL%	1.00	0.13	0.08
YDR	(0.049)	1.00	-0.82
ODR	(0.24)	(0.0)	1.00
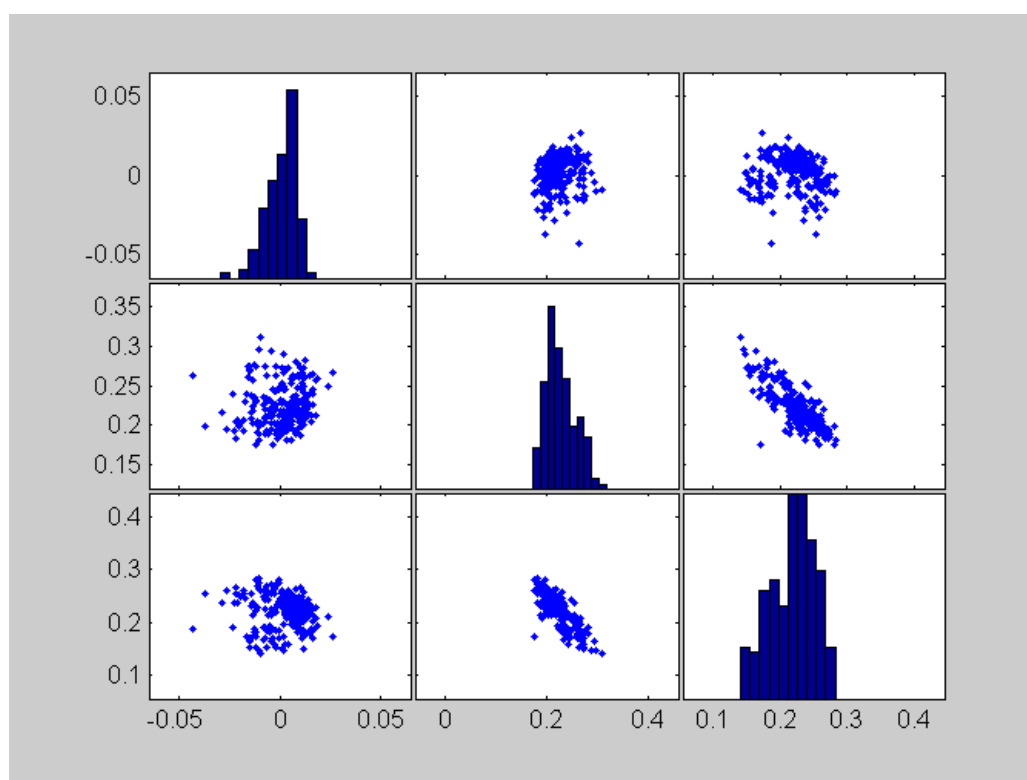
Figure 3.1: Scatterplot-matrix of employment growth and the dependency ratios YDR and ODR

From Figure 3.1 and the correlation Table 3.1 we see that the correlation coefficient between employment growth and the young dependency ratio is positive (and significant) while the correlation coefficient between GDP growth and the old dependency ratio is not significantly positive.

Table 3.2: Regression estimates for the simple employment model

OLS	coeff.	Conf-Int.	
	b	b_lower	b_upper
intercept	-0.024	-0.059	0.012
young DR	0.082	-0.011	0.174
old DR	0.029	-0.047	0.104
	R^2	F-Stat	p-value
	0.0195	2.2265	0.1103

Table 3.3: Regression estimates for the fixed effect model

OLS	coeff.	Conf-Int.	
	b	b_lower	b_upper
d_aut	0.0539	0.019	0.0887
d_sk	0.0516	0.018	0.0853
d_hu	0.0252	-0.0089	0.0594
d_ger	0.0478	0.0134	0.0823
d_p	0.0321	-0.0015	0.0656
d_cz	0.0315	-0.0006	0.0636
young	-0.0192	-0.1054	0.067
old	-0.1859	-0.2686	-0.1032
	R^2	F-Stat	p-value
	0.3604	17.6278	0

From the simple regression model we see that the R^2 is very low and both regression coefficients have a positive sign. Again by the looking at the fixed effect model, we see that the R^2 is about he same size as for the GDP growth model and both coefficients are estimated negatively. The YDR coefficient is not significant while the ODR coefficient has the same size as in the GDP growth model. For the employment model it is possible that the negative relationship might not reflect a direct economic connection, rather we suspect it is the indirect connection via GDP growth.
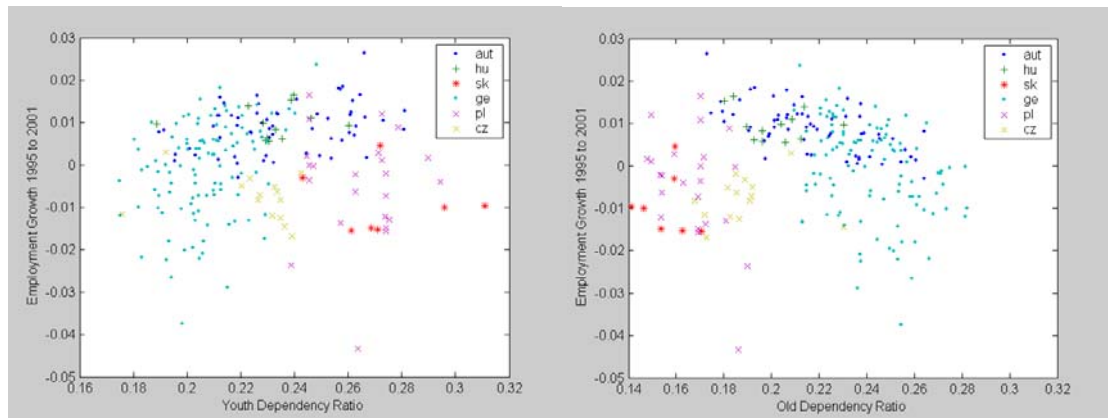
Figure 3.2: Scattergrams of employment growth with YDR and ODR

3.1 Long-term forecast implications for employment growth

In the simple model we estimated the annual employment growth based on youth and old dependency ratios (and the fixed effects) and we calculated the fit 2000 and the forecasts 2020. As before, we compute the difference between the fitted values for 2000 and the forecasted values for 2020.
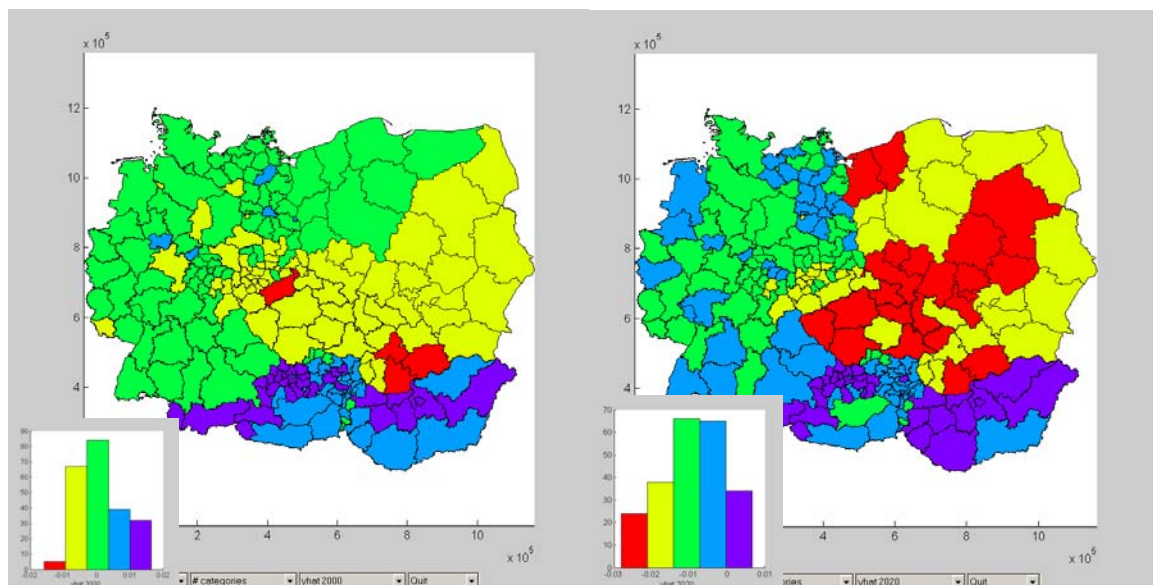
Figure 3.3: Estimated EMPL% values (yhat)
for 2000

Figure 3.4: Forecasted EMPL% values (yhat)
for 2020
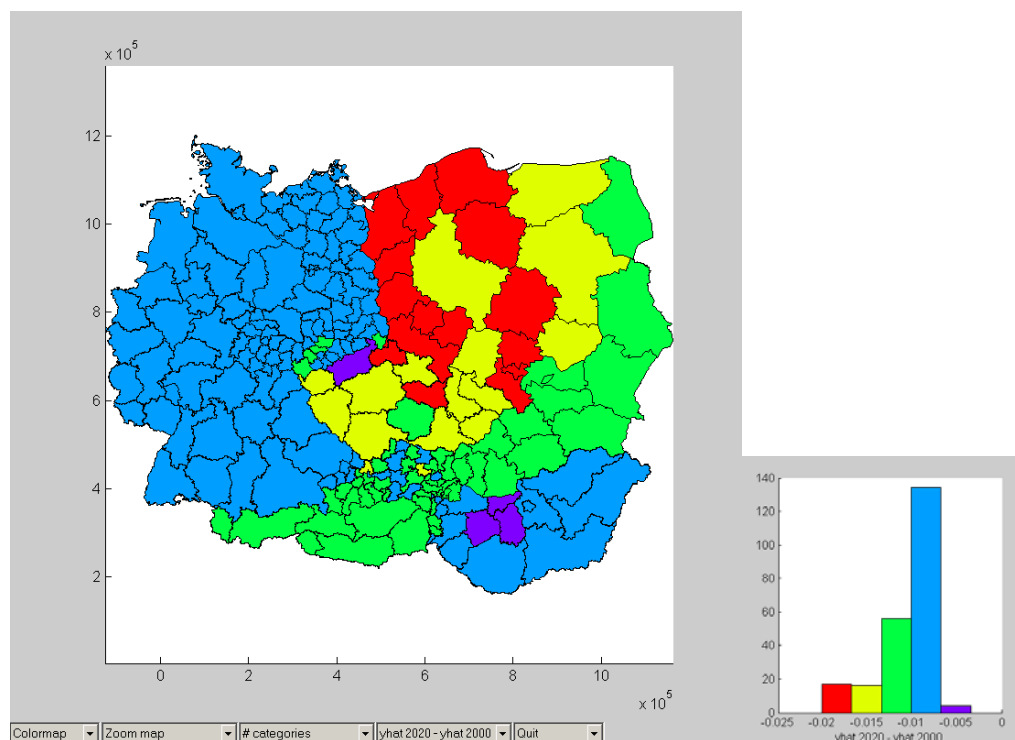
Figure 3.5: Differences (of yhat) between 2020 and 2000

From Figure 3.3 we see that the simple model explains (i.e. the effects of the population structure) high employment growth rates in Austria and Hungary, zero employment growth effects for most German regions, while only some shrinking employment growth effects for Slovakia and Czech Republic.

Figure 3.4 predicts for the year 2020 by the simple model positive employment growth effects for almost all regions in Hungary and Austria (except upper Styria and the northern lower Austria). German regions are very mixed: some stay with zero employment growth effects, but several other regions can improve, like e.g. in Bavaria, Baden-Würtenberg, Frankfurt and the regions around Berlin. Surprisingly we find on the loser side most of the regions in the Czech Republic and Poland, where surprisingly the regions west of Warsaw are negatively affected but the regions at the eastern border are not.

Figure 3.5 shows the difference of the employment growth rates due to the influence of the population structure. Through all the regions we see a negative EMPL% contribution. The highest reductions are expected for western Poland and the lowest growth losses for Hungary. Germany and Hungary are less affected by the population structure than Austria and SK.

3.2 Long Term Forecasts and Traffic Infrastructure (TI)

Table 3.4: Regression estimates for EMPL structure (PS) and traffic infrastructure (TI)

Ordinary Least-squares Estimates			
Dependent Variable	=	Avg LOG EMPL growth 1995-2001	
R^2	=	0.3952	
Adj. R^2	=	0.3613	
σ^2	=	0.0001	
Durbin-Watson	=	1.9476	
Nobs, Nvar	=	227	13
**			
Variable	Coefficient	t-statistic	p-value
youth dep. ratio	-0.018	-0.3	0.73
old dep. ratio	-0.172	-3.8	0.00
nodes per highway-km	0.009	1.1	0.27
highway per km2	0.048	1.6	0.12
Roads per km2	-0.034	-2.1	0.04
Railstation per km	0.038	1.0	0.30
Railnet per km2	0.000	0.0	0.98
d_aut	0.051	2.4	0.02
d_sk	0.049	2.4	0.02
d_hu	-0.018	-0.3	0.73
d_ger	-0.172	-3.8	0.00
d_p	0.009	1.1	0.27
d_cz	0.048	1.6	0.12

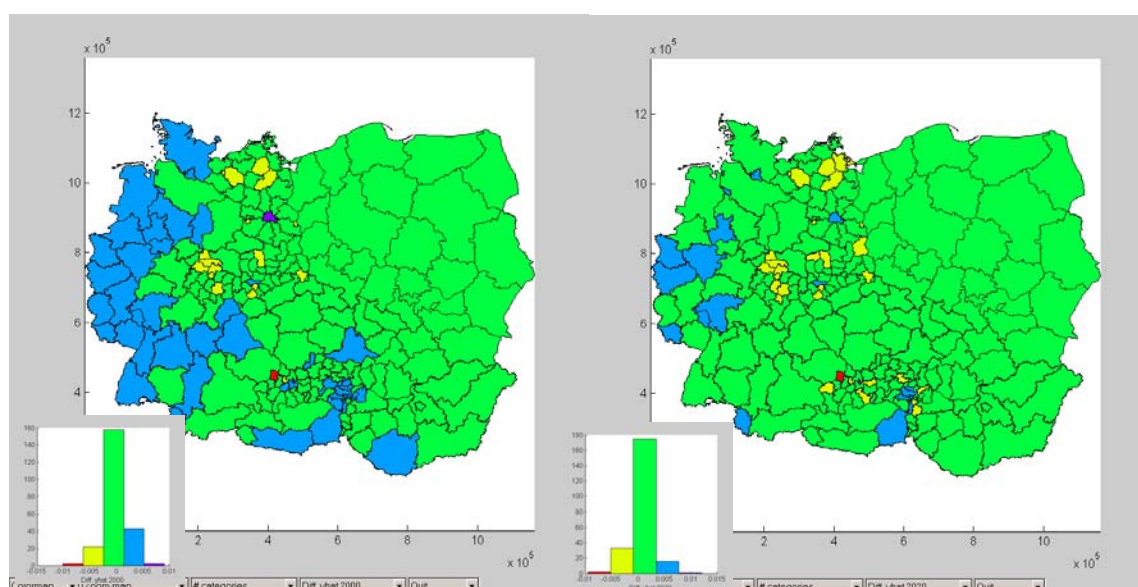**Figure 3.6a**: Difference of average EMPL% fits (yhat 2000(PS&TI) – yhat 2000(PS)) due to Traffic Infrastructure.

Figure 3.6b: Difference of average EMPL% forecasts (yhat 2020(PS&TrInf) – yhat 2020(PS)) due to Traffic infrastructure.

Figure 3.6a shows that the difference of EMPL% rates due to traffic variables is around 0 for most of the regions but positive for western German regions along the Rhine valley. Also some regions in Austria will benefit, while some regions in Eastern Germany were not affected by traffic infrastructure. The forecast of these differences for the year 2020 in Figure 3.6b is less favourable since more regions are 0 or slightly small positive.

3.3 Long Term Forecasts and Dynamic Structure (DS)

The next Table 3.5 shows the regression estimates for the full model, i.e. using Population structure, Traffic infrastructure and dynamic components:

Table 3.5: **Regression estimates for EMPL structure (PS), traffic infrastructure (TI) and time dynamics (DYN)**

Ordinary	Least-squares	Estimates	
Dependent Variable =	=	Avg LOG EMPL growth 1995 – 2001	
R^2	=	0.8615	
Adj. R^2	=	0.8502	
σ^2	=	0	
Durbin-Watson	=	1.4932	
Nobs,	=227,	Nvar	18

****

Variable	Coefficient	t-statistic	p-value
Lempl_95_96	0.120	11.9	0.00
Lempl_96_97	0.161	13.3	0.00
Lempl_97_98	0.184	14.0	0.00
Lempl_98_99	0.117	6.4	0.00
Lempl_99_00	0.194	12.1	0.00
youth dep. ratio	-0.046	-1.8	0.07
old dep. ratio	-0.050	-2.2	0.03
nodes per highway-km	0.005	1.2	0.24
highway per km^2	0.019	1.2	0.22
Roads per km^2	-0.011	-1.3	0.18
Railstation per km	0.027	1.5	0.13
Railnet per km^2	-0.007	-0.7	0.47
d_aut	0.023	2.2	0.03
d_sk	0.022	2.2	0.03
d_hu	0.021	2.1	0.04
d_ger	0.020	2.0	0.05
d_p	0.018	1.9	0.06
d_cz	0.020	2.1	0.03
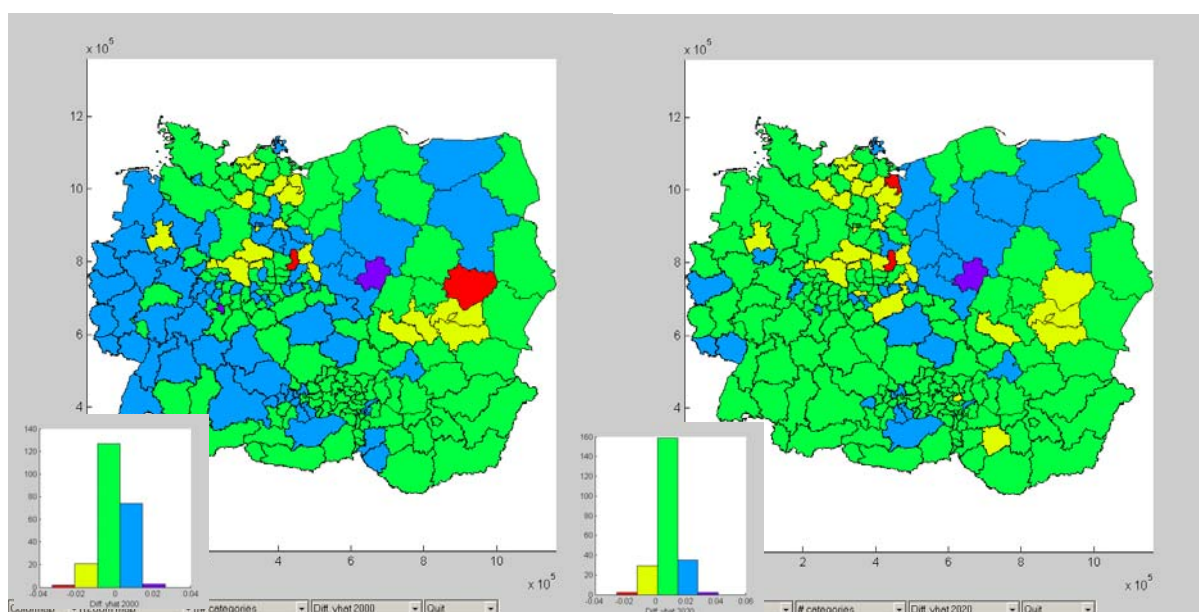
Figure 3.7a: Difference of EMPL% fit (yhat 2000 (PS & TI & Dyn) – yhat 2000(PS & TI)) due to time dynamics

Figure 3.7b: Difference of EMPL% forecasts (yhat 2020(PS&TI&Dyn) – yhat 2000(PS&TI)) due to time dynamics

Figure 3.7a shows the difference of EMPL% rates with respect to time dynamics. We see that only a few cells in Eastern Germany and southern Poland were negatively affected. In the long run for 2020 we see that dynamic time effects are only large for the western and central regions in Poland. Employment growth does not respond heavily to short-term time dynamic effects for most of the other regions

Table 3.6: R^2 Increase by model nesting EMPL%

	R^2	Diff. R^2
PS	0.0195	0
6D (country dummies)	0.2737	0.25
6D + PS (population structure)	0.3604	0.09
6D + PS + TI (Traffic infrastructure)	0.3952	0.03
6D + PS + TI + Dyn (lagged dep. variables)	0.8615	0.47

From Table 3.6 we see that the country dummy variables explain 25% of the R^2, the population structure 9% and the traffic infrastructure 3%. The largest amount, 47% is due to the dynamic component.

4. Population growth and population structure

Table 4.1: **Correlation matrix of population growth and the dependency ratios YDR and ODR (p-values in parenthesis)**

(p-val)	GDP%	YDR	ODR
GDP%	1.00	0.26	-0.23
YDR	(0.0)	1.00	-0.82
ODR	(0.0)	(0.0)	1.00

First we notice from Table 4.1 and Figure 4.1 that population growth is positively correlated with the YDR and negatively with the ODR.
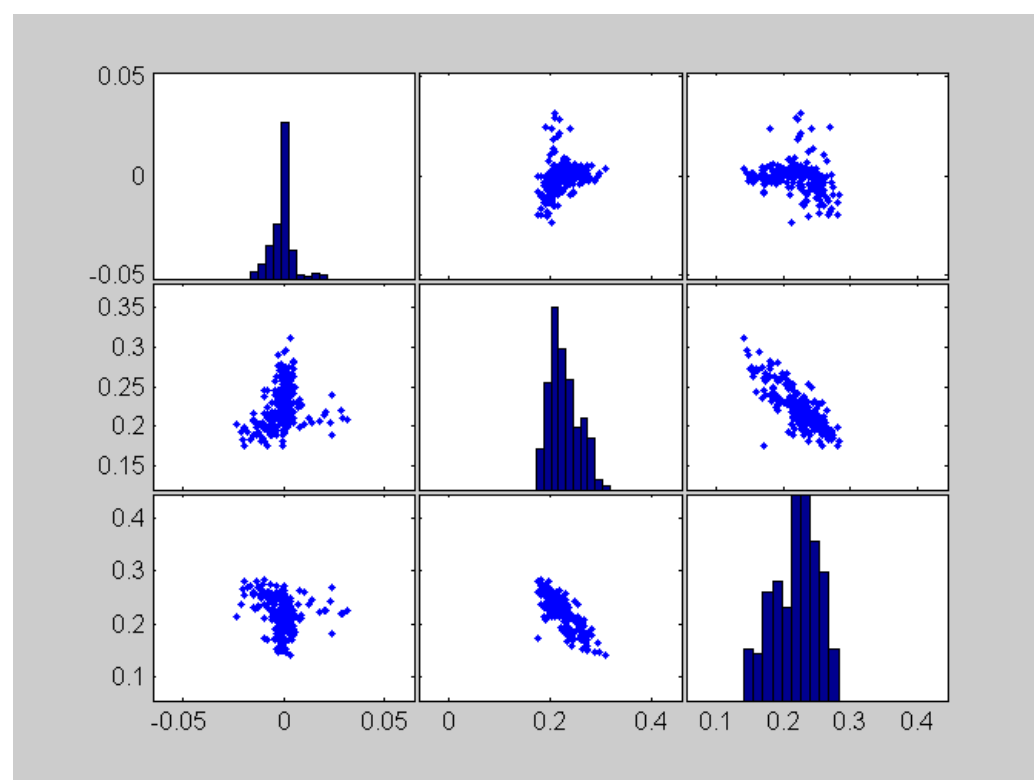
Figure 4.1: **Scatterplot-matrix of population growth and the dependency ratios YDR and ODR**

Table 4.2:   Regression estimates for the simple population model

OLS	coeff.	Conf-Int.	
	b	b_lower	b_upper
intercept	-0.0123	-0.0373	0.0128
young DR	0.0639	-0.0009	0.1287
old DR	-0.0126	-0.0658	0.0406
	R^2	F-Stat	p-value
	0.0684	8.2254	0.0004

Table 4.3:   Regression estimates for the fixed effect model

OLS	coeff.	Conf-Int.	
	b	b_lower	b_upper
d_aut	0.012	-0.0167	0.0407
d_sk	0.0098	-0.0179	0.0375
d_hu	0.0016	-0.0266	0.0297
d_ger	0.0125	-0.0158	0.0409
d_p	0.0016	-0.026	0.0292
d_cz	0.0063	-0.0202	0.0327
young	0.0563	-0.0147	0.1273
old	-0.1079	-0.1761	-0.0398
	R^2	F-Stat	p-value
	0.1619	6.0434	0

The simple regression model has a very poor fit (R^2 = 6.8%) but the F-statistic is significant and the sign of the regression coefficients follow the signs of the bivariate correlations of the correlation matrix. In the fixed effect model the sign pattern is confirmed and the negative effect of the ODR is more pronounced. A 10 bp increase in the ODR will reduce on average the population growth by 1.1%-point while a 10 bp increase in the YDR will stimulate the population growth by 0.6%-point. Note that even if the size of the old and young population group would be equal the net effect would be negative on the population growth.
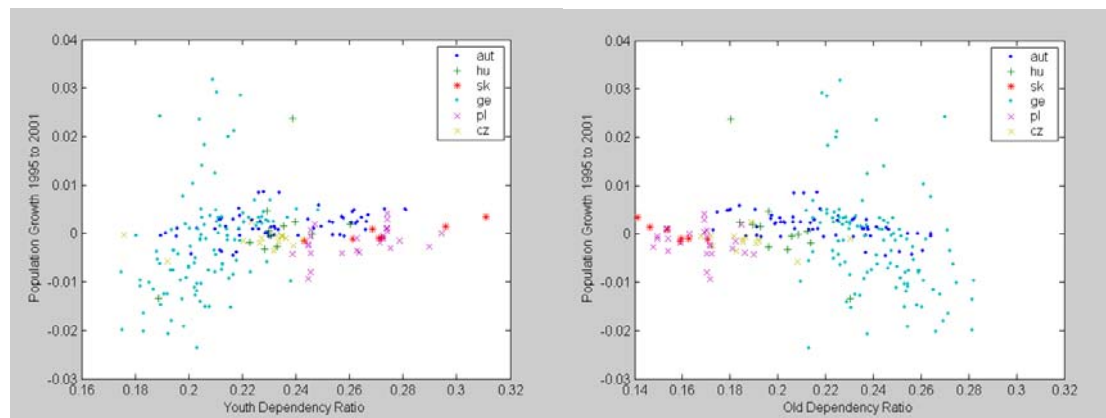
Figure 4.2: Scattergrams of GDP% with YDR and ODR

4.1 Long Term Forecast Implications

As before, we explore the forecast behaviour of the model with respect to the population growth. In Figure 4.3 and 4.4 we have estimated annual population growth based on youth and old dependency ratios for the years 2000 and 2020.
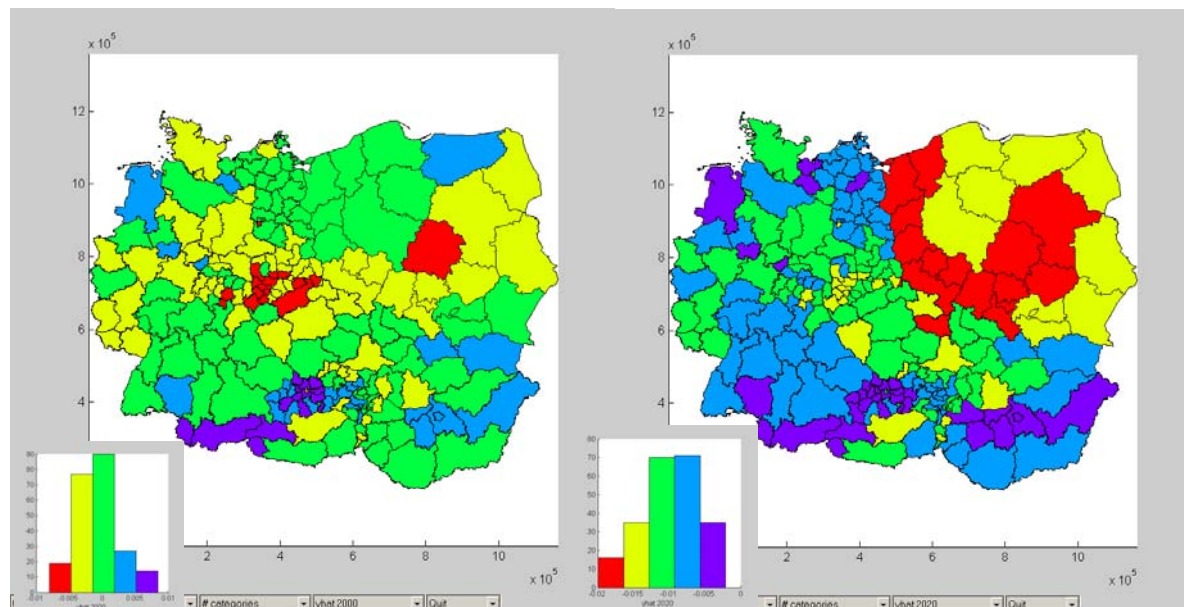
Figure 4.3: Estimated Pop% values (yhat) for 2000

Figure 4.4: Forecasted POP% values (yhat) for 2020
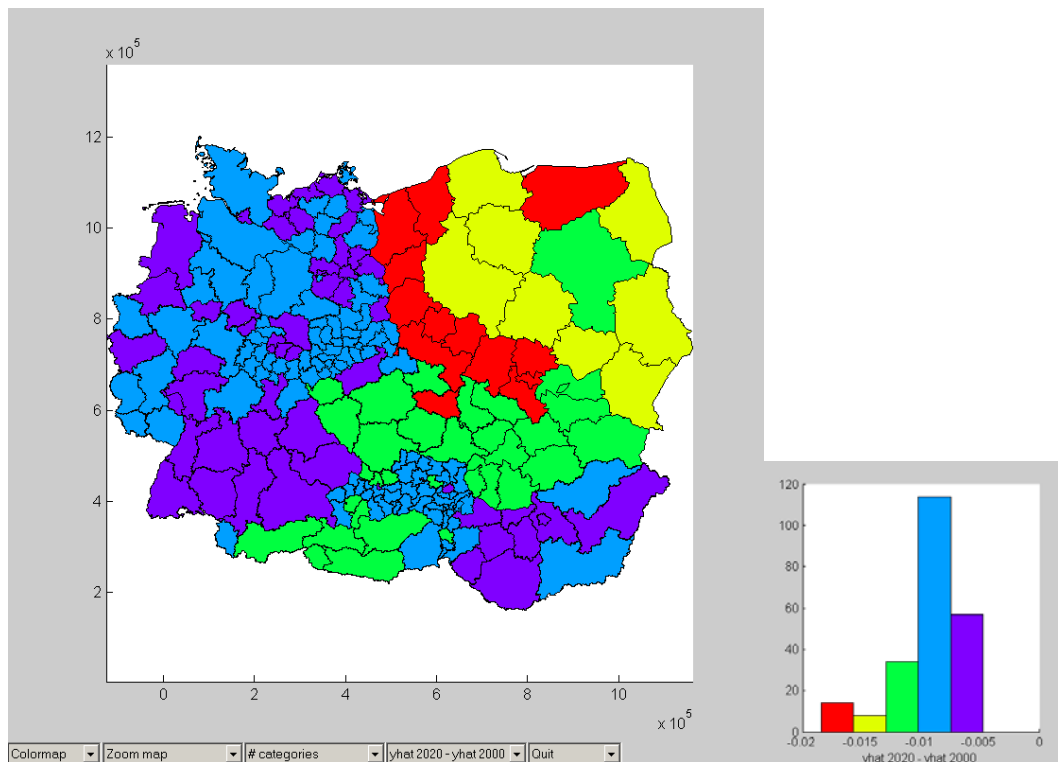
Figure 4.5: Differences (of yhat) between 2020 and 2000

From Figure 4.4 we see that the model for population growth fits a bimodal distribution, where most of the German regions belong to the low growth group of about 1.8% and many of the Austrian regions, together with a band of regions stretching from Slovakia along the eastern border of Poland belong to the high growth group of 3%. The picture of the population growth rate distributions again bimodal if we look at the model forecasts of 2020 in Figure 4.5. The forecasts for most of the German regions are just below 1% and for the Polish and Slovak regions it is between 2% and 3%. If we look at Figure 4.5 to see where the main losers of the population growth forecasts due to a shifting population structure are, we see that Germany, Slovakia and Hungary are reducing the growth rate marginally, while in the central band the regions from the Alps to the Baltic Sea the reduction of the population growth rate is on average about 1%. Also we see that the forecast of the population growth follows roughly the pattern of the forecasts of the employment growth rates.

4.2 Long Term Forecasts and Traffic Infrastructure (TI)

Table 4.3: Regression estimates for population structure (PS) and traffic infrastructure (TI)

Ordinary Least-squares Estimates			
Dependent Variable	=	Avg LOG POP growth 1995 – 2001	
R^2	=	0.2039	
Adj. R^2	=	0.1593	
σ^2	=	0.0001	
Durbin-Watson	=	1.7656	
Nobs,	=227	Nvars =	13
**			
Variable	Coefficient	t-statistic	p-value
youth dep. ratio	0.034	0.8	0.43
old dep. ratio	-0.099	-2.7	0.01
nodes per highway-km	0.008	1.2	0.23
highway per km^2	0.025	1.0	0.32
Roads per km^2	-0.014	-1.0	0.31
Railstation per km	-0.010	-0.3	0.75
Railnet per km^2	-0.014	-0.9	0.37
d_aut	0.017	1.0	0.32
d_sk	0.014	0.9	0.40
d_hu	0.034	0.8	0.43
d_ger	-0.099	-2.7	0.01
d_p	0.008	1.2	0.23
d_cz	0.025	1.0	0.32
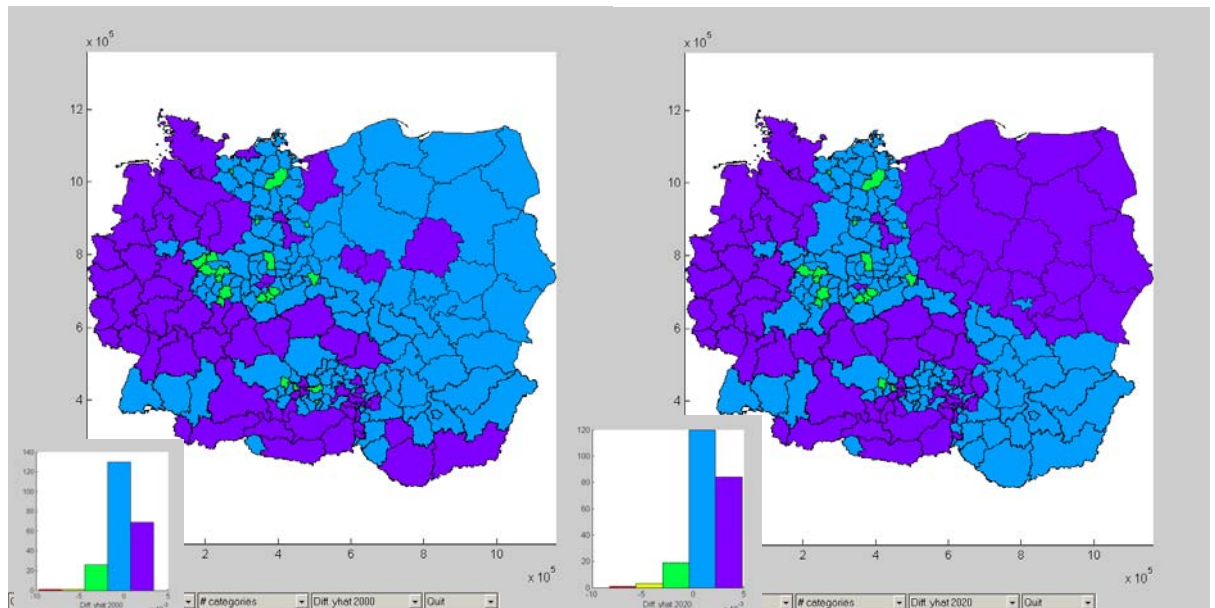
Figure 4.6a: Difference of average population fit (yhat 2020(PS&TI) – yhat 2000(PS)) due to Traffic Infrastructure

Figure 4.6b: Difference of population forecasts (yhat 2020(PS&TI) – yhat 2020(PS)) due to Traffic Infrastructure

In Figure 4.6a we see the difference of the average population fit due to traffic infrastructure. We see that the positive growth differences for 2000 are in the majority and surprisingly more population growth was observed in western region than in the east. The forecast for 2020 in Figure 4.6b shows a different picture: All Polish regions are profiting from traffic impulses, the Alpine regions in Austria and Western German regions. Only a few regions will get negative impulses.

In Figure 4.7a we see that for the estimates in the model time dynamics was not contributing to population growth. Only the ring of regions around Berlin was profiting from a new dynamic at the end of the 90ies. Other Eastern German regions lost due to the dynamic component, as well as regions in Moravia and southern Austria. The forecast for 2020 can be seen in Figure 4.7b: Zero growth differences are only expected in a few regions, most of the in Eastern German. Most regions are getting positive impulses from time dynamics.

4.3 Long Term Forecasts and Dynamic Structure (DS)

Table 4.3:   Regression estimates for population structure (PS), traffic infrastructure (TI) and time dynamics (DYN)

Ordinary Least-squares Estimates			
Dependent Variable	=	Avg LOG POP growth 1995 - 2001	
R^2	=	0.911	
Adj. R^2	=	0.9037	
σ^2	=	0	
Durbin-Watson	=	2.0796	
Nobs, Nvars	=	227,	18
Variable	Coefficient	t-statistic	p-value
Lpop_95_96	0.055	0.8	0.41
Lpop_96_97	0.151	3.3	0.00
Lpop_97_98	0.282	6.0	0.00
Lpop_98_99	0.237	3.7	0.00
Lpop_99_00	0.370	8.8	0.00
youth dep. ratio	0.000	0.0	0.98
old dep. ratio	-0.002	-0.1	0.90
nodes per highway-km	0.003	1.4	0.18
highway per km^2	-0.009	-1.0	0.33
Roads per km^2	0.004	0.7	0.45
Railstation per km	-0.002	-0.2	0.86
Railnet per km^2	-0.001	-0.2	0.86
d_aut	0.000	0.0	0.98
d_sk	0.006	1.0	0.33
d_hu	-0.001	-0.1	0.90
d_ger	0.000	0.0	0.98
d_p	-0.002	-0.3	0.73
d_cz	0.001	0.2	0.86
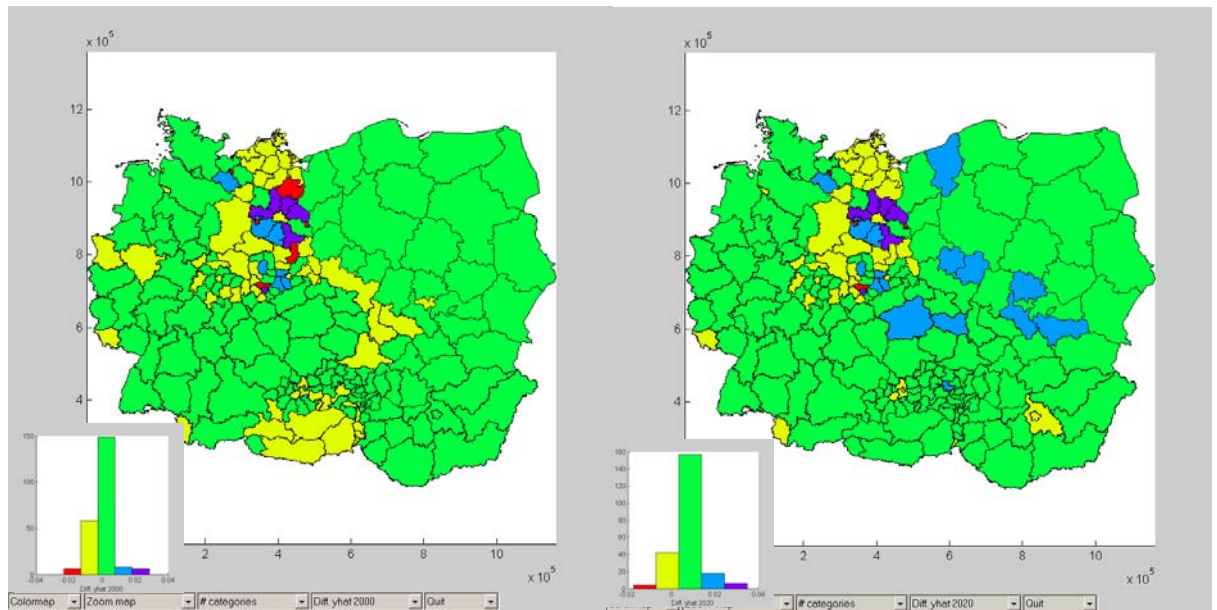
Figure 4.7a: Difference of average population fit (yhat 2000(PS&TI&Dyn) – yhat 2000(PS&TI)) due to time dynamics

Figure 4.7b: Difference of POP% forecasts (yhat 2020(PS&TI&Dyn) – yhat 2020(PS&TI)) due to time dynamics

Table 4.7: R^2 Increase by model nesting for POP%

PS	R^2	Diff. R^2
6D (country dummies)	0.0405	
6D + PS (population structure)	0.1619	0.12
6D + PS + TI (Traffic infrastructure)	0.2039	0.04
6D + PS + TI + Dyn (lagged dep. variables)	0.911	0.71

Table 4.7 shows that 71% of the R^2 measure can be explained by the past population dynamics. The traffic infrastructure component is weak; the population structure contributes 3 times as much to the model fit, namely 12%.

5. A CART Analysis

In Figure 5.1 we estimated a classification and regression tree (CART) model for the GDP growth rate model. We see that the first variable to build a tree is the splitting of the distribution by the variable YDR. The R^2 of the model is 0.365.

If YDR is less than 24% the regional GDP growth decreases to 1.9% otherwise it increases to 3.3% (this was the case for about ¼ of the regions. If in the low GDP growth group the ODR is above 20% then the GDP growth declines to 1.5%, otherwise it increases slightly to 2.2%. In the upper branch we see that the fastest growing regions were those, where the number of rail stations was low (but these were only six cells). But "on top" to this phenomenon we see that the regional GDP growth can be boosted if the ODR is less than 10%: Growth goes up to 3.5%.

In Figure 5.2 we estimated a classification and regression tree (CART) model for the employment growth rate (EMPL). We see that the first variable to define a tree is the splitting of the distribution by the variable GDP per employee (GDP_pw). The R^2 of the model is 0.335.

We see that for regions with a high GDP per employee the EMPL growth rate is 6.0% while for low GDP per employee the EMPL growth rate is –1%. This shrinking EMPL growth rate can only be turned into a positive growth rate of the YDR is larger than 27%. Then the EMPL growth rate is 5.8%, but only 16 regions fulfil this condition. Otherwise we see that the EMPL growth rate drops further, down to –4.3%, and this trend in only reversed at the –1% level if the old ODR is less than 25%. (These have been 98 regions in the period 1995-2001.)
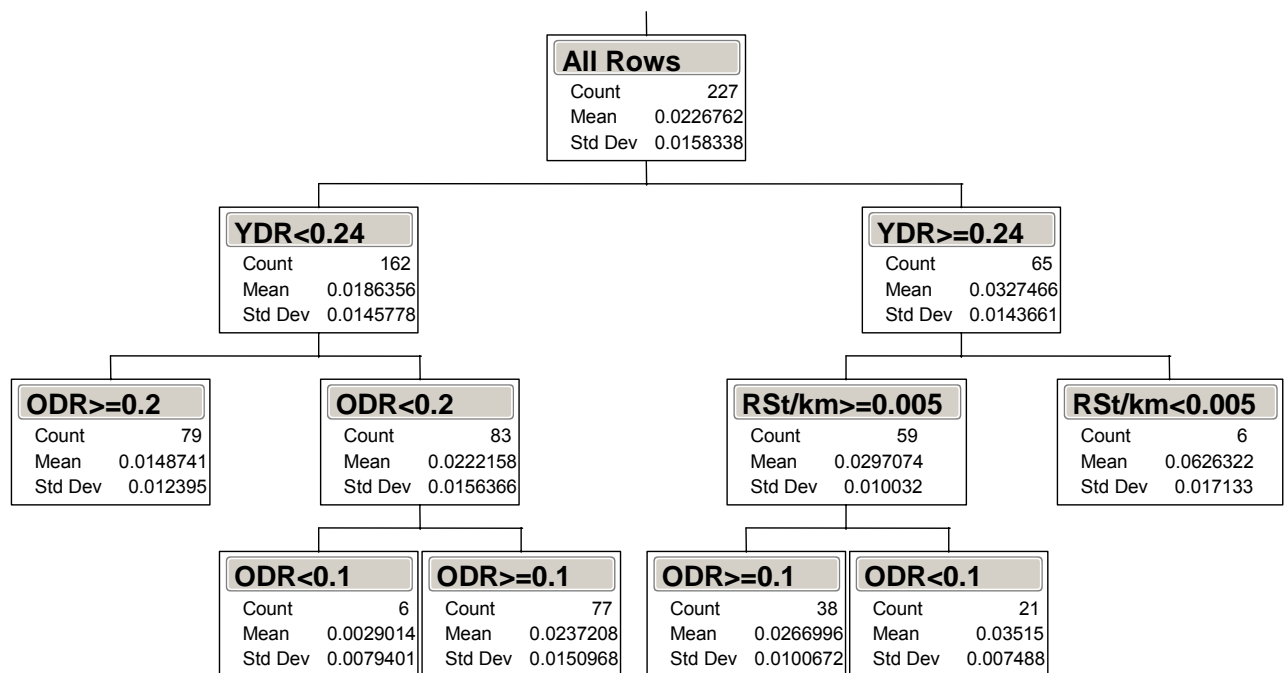
All Rows

Count	227
Mean	0.0226762
Std Dev	0.0158338

YDR<0.24

Count	162
Mean	0.0186356
Std Dev	0.0145778

YDR>=0.24

Count	65
Mean	0.0327466
Std Dev	0.0143661

ODR>=0.2

Count	79
Mean	0.0148741
Std Dev	0.012395

ODR<0.2

Count	83
Mean	0.0222158
Std Dev	0.0156366

RSt/km>=0.005

Count	59
Mean	0.0297074
Std Dev	0.010032

RSt/km<0.005

Count	6
Mean	0.0626322
Std Dev	0.017133

ODR<0.1

Count	6
Mean	0.0029014
Std Dev	0.0079401

ODR>=0.1

Count	77
Mean	0.0237208
Std Dev	0.0150968

ODR>=0.1

Count	38
Mean	0.0266996
Std Dev	0.0100672

ODR<0.1

Count	21
Mean	0.03515
Std Dev	0.007488

Figure 5.1: Partitioned CART model for GDP growth

All Rows

Count	227
Mean	0.0142247
Std Dev	0.0689832

Lgdp_pw<3.77

Count	150
Mean	-0.00946
Std Dev	0.0668715

Lgdp_pw>=3.77

Count	77
Mean	0.0603636
Std Dev	0.0460411

YDR<0.27

Count	134
Mean	-0.017455
Std Dev	0.0619848

YDR>=0.27

Count	16
Mean	0.0575
Std Dev	0.0707069

ODR>=0.25

Count	36
Mean	-0.042972
Std Dev	0.0610875

ODR<0.25

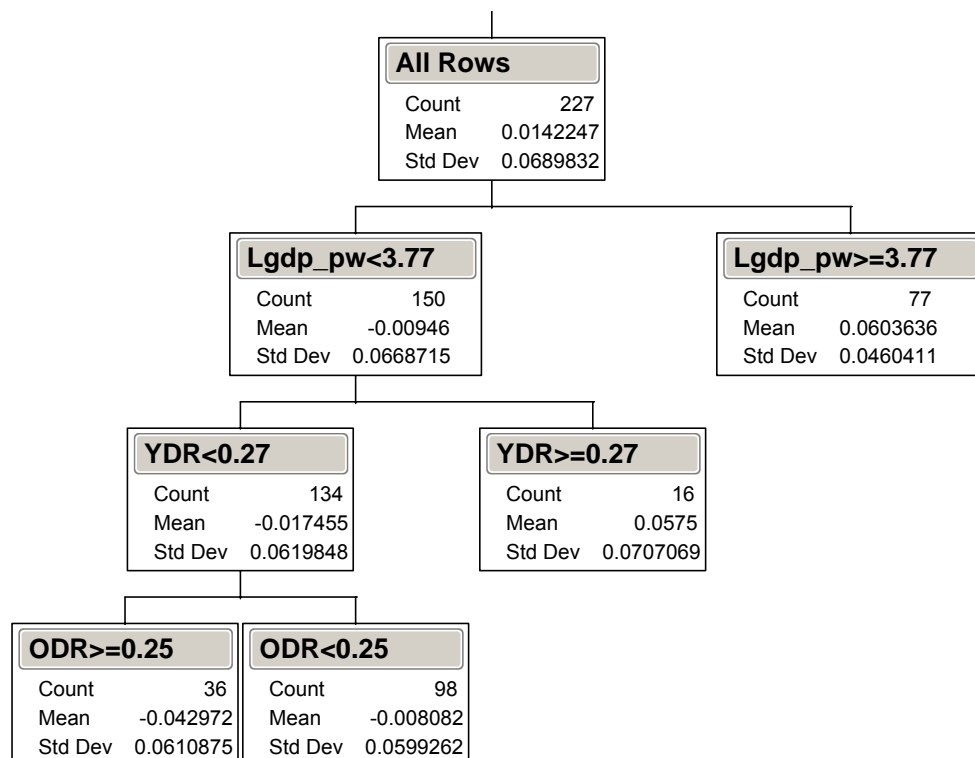|	
Count	98
Mean	-0.008082
Std Dev	0.0599262

Figure 5.2: Partitioned CART model for EMPL %

6. Conclusions

The simple forecasting exercise has shown that the regional GDP growth rates will suffer heavily from the age structure, i.e. the dependency ratios in the year 2020. If no other factors will dominate GDP growth in future, the regional growth rate which was observed until 2001 in central Europe will be not sustainable in the future.

The size of the effects varies across countries: While GDP growth in Germany, Hungary and Slovakia will be almost not affected by a changing population structure, most regions in Poland, Austria and the Czech Republic will suffer from adverse population structure effects. Interestingly, the employment rate depends only significantly negatively from the ODR, while the population growth depends positively on the ODR and YDR. The forecast scenarios for 2020 show very different pattern in the six central European countries of regional growth according to the three variables GDP, employment and population growth.

The main findings of the study are:

1) All six central European countries suffer growth losses due to an aging population structure until 2020. This aging population stress will affect annual growth in some regions up to 2% points per year.

2) This adverse age effect is offset by favourable stimuli stemming from improved infrastructure investment, like railways or roads. Traffic infrastructure will benefit in first line big centre (or metropolitan) regions and such effects will spill over in the surrounding regions (neighbourhood effects: this has been seen very clearly for the 5 regions around Berlin.) On average, the adverse population aging effect will be offset by the positive affect of infrastructure on growth.

3) Many important influences on regional growth could not be measured and therefore we see a large dynamic component dominating the long-term forecasting behaviour. Since the dynamic component could only be observed for a short period it is unclear if this observed trend will last until the year 2020. Important effect like the migration component was not part of the regional model, since it was impossible to get reliable yearly data for all the cells in the six central European countries.

4) In summary regional GDP growth in central European regions will be rather constant in the next one or two decades. Only in some regions we will observe a dynamic process, which will have rather specific regional reasons. Thus there will be room for many regional success stories, but no simple overall recipe can be concluded from the dynamic panel model. Thus regional growth, which will be larger than the current basic zero growth outlook, will be based on very heterogeneous dynamic regional components.

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