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Zentralbahnhof Wien as an engine for regional growth: Improved accessibility fosters firm growth

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1 ABSTRACT

Using the IHS EAR model the long-term economic impact of the planned central station in Vienna is analyzed. A dynamic regional panel model measuring spatial dependencies with travel times between the 99 political districts in Austria and central Europe is used. The new central station "Zentralbahnhof Wien" will lead to improvements mainly along the Eastern-Western axis. Firm growth in regions around Vienna is likely to be boosted leading to additional employment and economic growth. The attractiveness of these regions is further improved with respect to higher migration. The estimation of the model relies on potentials of economic variables, which are calculated using travel times and frequencies. Bayesian Model Averaging (BMA) allows robust estimates and the forecast based on improved travel times.

2 INTRODUCTION

Aschauer (1989) investigated the effects of public infrastructure following a production function approach and found the social rate of return of public infrastructure to be substantial. It should be noted however that his study was based on national level data, whereas studies conducted on the regional or metropolitan area levels found much smaller effects. (compare ECMT, 2000) This may be due to the fact that the regional level effect of improving traffic infrastructure is more or less ambiguous on this level. This can be explained by the New Economic Geography literature, which stresses the role of centrifugal and centripetal forces. An improvement of infrastructure and therefore a decline in transportation costs will on the one hand benefit the firms in a core area by enlarging their market, on the other hand benefit the firms in remoter areas by increasing their competitiveness. (Krugman, 1991)

There literature on the assessment of improving the infrastructure or building new infrastructure is based on growth accounting approaches (compare Baum & Kurte, 2001), CGE modeling (compare Bröcker et al. (2004), Steininger et al. (2007)) as well as econometric modeling (compare Lall (2007), Polasek & Schwarzbauer (2006)). In this paper we follow an econometric approach, as we want to test whether infrastructure improvements will lead to improvements in economic performance, measured by GDP, firms and employment. The variable used to identify the improvement in traffic infrastructure is accessibility of regions.

Accessibility is believed to be one of the engines of modern economic growth, between countries and also for regions. Surprisingly, there is little empirical evidence that shows the connection between accessibility and regional growth. This paper demonstrates that modern spatial econometrics allows modeling this "missing link" between regional economic indicators, like GDP, employment or migration and rail traffic.

We will describe a dynamic panel model that builds on regional data for the period 1995-2005 for 99 Austrian regions ("politische Bezirke"). This model is called EAR (economic accessibility and regional) model, because it treats regional growth as a function of infrastructure, regional economic indicators, demographics, and traffic related accessibility. Until recently, the data base on a regional level was quite unreliable, even more so for smaller units. But our analysis shows that time is ripe to explore economic relationships at a finer level, like political districts, as it was not possible in the past. Note that political districts would correspond to a NUTS 4 level that is officially supported by EUROSTAT, as the next possible level is LAU 2, which corresponds to the Austrian communities. Thus, this is good news for traffic planning, since the demand for more reliable data analysis was rising in the past.

In this application of the Austrian EAR model we will mainly focus on 4 regional economic indicators: GDP growth, employment growth, firm growth and migration. For all of these indicators we will estimate a dynamic panel model and make a 30-year prediction, where we use next to the dynamic behavior of the model the improved accessibility as a major stimulus of future growth.

While the general model can discriminate between train and road accessibility and between short-distance and long-distance accessibility, we will focus in this application on train accessibility. Since train accessibility is a quite general concept, we have tried to focus this type of accessibility on three more traffic related features: a) travel times, b) frequency of connections, and c) traffic volume. With this additional information we were able to construct accessibility variables that connect to the economic indicators that are the focus variables in the EAR model. Interestingly, as the estimation results show, different accessibility indices are driving economic activities in the Austrian regions and lead to parsimonious forecasting models. Furthermore we show that right modeling of the spatial dimension is also important to produce reliable model results.

In the next section we describe briefly the EAR model for the Austrian 99 regions. We next define in more detail the accessibility concept that underlies the present study, like the definition of "potentials": These are variables that relate and embed economic activities with their spatial neighbors. In section 4 we discuss our estimation results and in section 5 we describe our forecasting results for the main focus variables. A final section concludes.

3 THE MODEL

3.1 General Structure of the EAR model for Austria

Figure 1 summarizes the structure of the EAR (economic accessibility and regional) model. Regional growth is a function of infrastructure, regional structure, integration of regions, and traffic related accessibility.

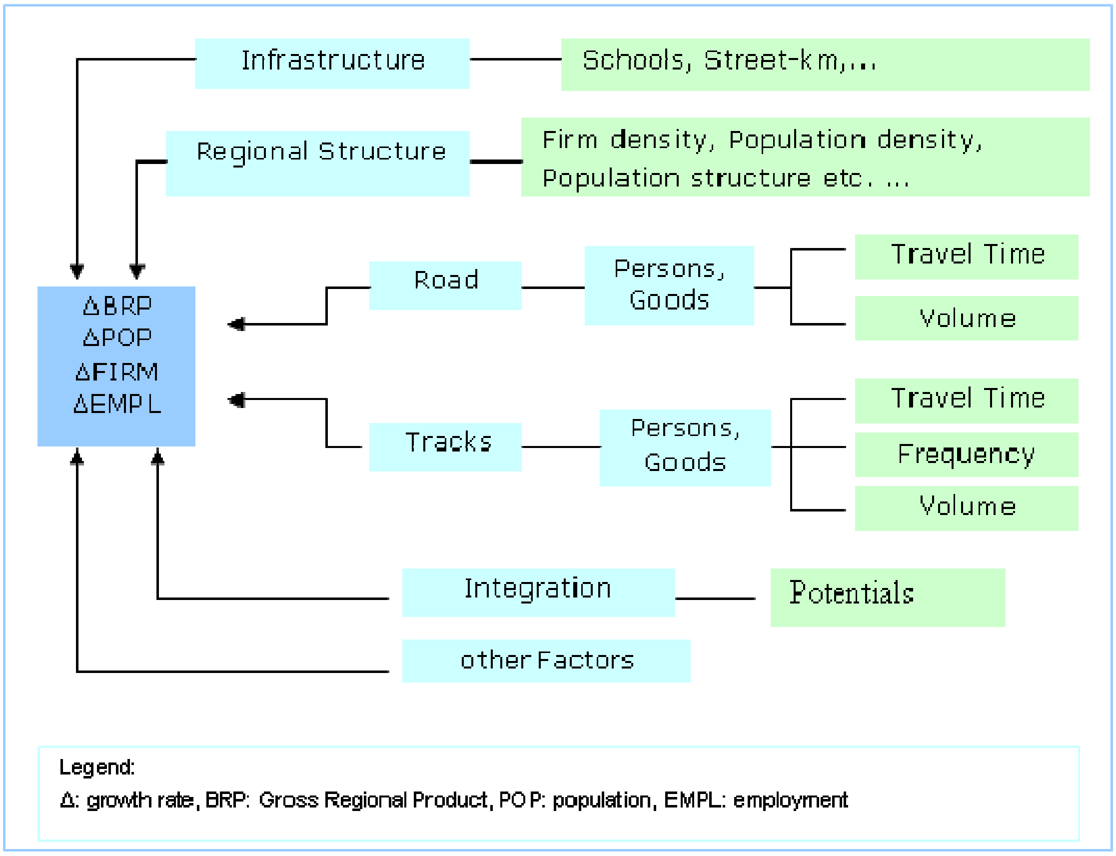

Figure 1: Structure of the EAR model

Infrastructure is an important factor for economic growth and development of a region. A well-developed infrastructure ensures mobility of production factors within and across economies and should lead to a more efficient allocation and utilization of resources.

Demographic structures are an important determinant for regional developments, as e.g. in regions with an older population we cannot expect a high population growth. Another feature of the regional structure is the firm and population density. On average the prices of land in a region that is more densely populated will be higher. As a consequence the costs of establishing a firm will be higher in more densely populated areas.

As the role of accessibility was discussed in the previous section it will not be described further here.

3.2 Accessibility

As Polasek (2005) showed for central European countries, a travel time improvement and reduced transport costs will have positive effects on the growth of these regions.

Although it is a popular argument in regional politics, accessibility is difficult to measure directly and can only be approximated in an econometric model. (see Schürmann and Talaat, 2000 or Spiekermann and Neubauer, 2002 for a discussion on accessibility indicators and concepts). In this paper accessibility will be proxied in several ways. First of all, we will distinguish between train and roads and between short-distance and long-distance accessibility. Furthermore there are three more traffic related features to accessibility:

- Travel Times

Travel time is a central feature of accessibility as it is often related to either time or monetary costs for firms and for private persons.

- Frequency of connections

As in supply-driven public transport systems, like the railways, the number of connections from one region to another is important for its accessibility.

- Volume

The transport volume can be regarded as an indicator for the attractiveness of a region. Concerning goods transport volumes the flows between regions are an indicator of the market integration of these regions.

To implement the concept of accessibility, so-called accessibility indicators are constructed. Let $\mathbf{A} = (a_{ij})$ be a positive quadratic travel time matrix with $i = 1,..., N$ and $j = 1,..., N$. The distance[1] between the n regions is given in Matrix $\mathbf{B} = (b_{ij})$; on the main diagonal there are only zero entries. (Each element of matrix **A** corresponds to an entry in matrix **B** and has the same dimension) From these two matrices an indicator, which summarizes the accessibility of region i, can be calculated in the following way.

$$AI_i = \sum_{j=1}^{N} a_{ij} \cdot w_{ij}, \text{ where } w_{ij} = \frac{b_{ij}}{\sum_{j=1}^{N} b_{ij}}$$

The weights w_{ij} are normalised across rows and measure the relative distance of regions i and j in comparison with other regions. A large value of AI_i in region i corresponds to a low accessibility. This can be explained by considering two pairs of regions with the same distance between them ($b_{ij} = b_{i'j'}$, $i \neq i'$ and $j \neq j'$) then the travel time can be different ($a_{ij} \neq a_{i'j'}$), especially if the traffic infrastructure between the regions is different.

Table 1 shows the different accessibility indices based on different weighting schemes, which we will be used in the EAR model class. Note that long-distance (far) indices use distances as weights while the local (near) accessibility indices are calculated with the inverse distances as weights.

In addition to train based travel times we also include road based travel times, where AI_7 corresponds to AI_1, AI_8 corresponds to AI_2, using road instead of train travel times.

[1] Several concepts of distance are used in this study. We used road km-distances as well as the Euclidian distance. The Euclidian distance between two points a = (xa, ya) and b = (xb, yb) is defined as $d_{a,b} = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}$.

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Table 3: Summary of weighted Accessibility Indicators

Indicator *no.*	**Indicator name**	**Accessibility**	**Weight**
1	AI_1	Accessibility Far	$w_{ij} = \frac{b_{ij}}{\sum_{j=1}^{N} b_{ij}}$
2	AI_2	Accessibility Near	$w_{ij} = \frac{1/b_{ij}}{\sum_{j=1}^{N} 1/b_{ij}}$
3	AI_3	Frequency – weighted Accessibility Far	$w_{ij} = \frac{fq_{ij} b_{ij}}{\sum_{j=1}^{N} fq_{ij} b_{ij}}$
4	AI_4	Frequency – weighted Accessibility Near	$w_{ij} = \frac{fq_{ij}\left(\frac{1}{b_{ij}}\right)}{\sum_{j=1}^{N} fq_{ij}\left(\frac{1}{b_{ij}}\right)}$
5	AI_5	Volume – weighted Accessibility Far	$w_{ij} = \frac{vol_{ij} b_{ij}}{\sum_{j=1}^{N} vol_{ij} b_{ij}}$
6	AI_6	Volume – weighted Accessibility Near	$w_{ij} = \frac{vol_{ij}\left(\frac{1}{b_{ij}}\right)}{\sum_{j=1}^{N} vol_{ij}\left(\frac{1}{b_{ij}}\right)}$
Explanation $freq_{i,j}$...frequency between locations i and j $vol_{i,j}$ ...volume transported from location i to j			

3.3 Potential Variables

The potentials of a region have to be incorporated in the model, as these variables influence either directly or indirectly the economic attractiveness of a particular region. Potentials are based on the gravitational formula of Newton, (compare Stewart, 1947). Bigger masses (or in economic analogy: population, GDP, etc.) are more attractive than smaller masses relative to the distance of their barycentres. The economic barycentre can be the administrative and/or economic centers of regions.

The concept of potential variables can be extended to growth rates and be defined as follows:

Let $dist_{i,j}$ be the distance between the economic barycentres of regions i and j. The growth potential of region i is defined as follows:

$$Potential_i = \sum_{j=1}^{n} \frac{growth_i \cdot growth_j}{dist_{i,j}},$$

where i, j = 1,...,n.

From the equation above it can be seen that the potential variable depends inversely on the distance between the barycentres and positively on either one of the both growth rates. The distance variable can be interpreted also as a discount factor. In the EAR model various forms of distances are being considered, which can be either train or road travel times or coordinate distances.

Vickerman (1995) and Vickerman et al. (1997) define accessibility as a potential, i.e. the population or the economic activities that can be reached within a given time. Note that the definition of accessibility of Vickerman differs from the one used in this study. Here accessibility is viewed as a more general concept, where the availability of fast connections from a given region to all other regions determines this region's accessibility.

3.4 Data

The data on population, commuter flows were taken from the general database of Statistik Austria from 1995 to 2005. Data on firms and employment have been obtained from the Leistungs- & Strukturerhebung of Statistik Austria from 1998 – 2005. GDP data have been broken down to the 99 political districts from NUTS-3 level GDP by tax statistics. Travel times, connecting frequencies and individual traffic volumes as well as their changes have been provided by OEBB. Rail cargo volumes between the 99 political districts were obtained from the Statistik Austria for various years.

4 ESTIMATION RESULTS

4.1 GDP, Firms Employment and Migration

In a first step all the potentially influential variables are included into a BMA (Bayesian Model Averaging, see LeSage and Parent 2006 for spatial extension) analysis to select the most probable model. Given the selected variables, the final model for each variable is estimated using Bayesian routines and estimators. We estimate either a heteroskedastic linear model or a spatial autoregressive model based on the results of the BMA analysis[2]. (compare LeSage, 1997)

The ordinary linear model is given by the following equation

$$\Delta y_t = c + AI_t \alpha + \Delta x_t \beta + \varepsilon_t, \tag{1}$$

where Δy_{t_t} is the difference of the logged dependent variable (GDP, employment, number of firms or migration), c is a constant. AI_t is the selected set of accessibility indicators, Δx_t is the difference of the log of other explanatory variables included in the regression and ε_t is the vector of errors which are assumed to be heteroskedastic.

The SAR-model is found by adding a spatial lag to the equation above:

$$\Delta y_t = c + AI_t \alpha + \Delta x_t \beta + \rho W \Delta y_t + \varepsilon_t, \tag{2}$$

where W is a row-normalized matrix displaying spatial structures.

Overall the improvement of accessibility will lead to an overall increase in economic activity of Austrian regions. (compare table 2) The indicator that emphasizes local train connections (AI_2) is the main driver for economic activity.[3] This impact can be observed for all indicators of economic activity as well as for net migration. we observe a different picture for road accessibility. For the far road accessibility (AI_7) negative effects for GDP growth can be observed. Improving far road accessibility will on the other hand positively affect firm growth. The second road accessibility indicator weighting the connection to local destinations stronger (AI_8), will positively affect GDP growth, and negatively affect employment and firm growth.

For GDP growth a significant time lag was also found to influence contemporaneous GDP growth. Lagged neighboring GDP growth was found to be a determinant of firm growth. This means that if GDP growth accelerated in the past in neighboring districts, firm growth would also accelerate in the subsequent period. The spatial dependence was modeled using inverse travel times between the districts. For employment growth we find that firm growth appeared to be of a positive influence.

The last column in Table 2 presents the estimation results for migration. Accessibility indicators 1-3 enter the equation significantly, even though indicator number 1 displays the opposite sign. Summing the effects, however, we observe that improving the accessibility of a particular region will improve the net migration statistic by either increasing the number of immigration to that region or reducing the emigration from that particular region.

These effects remain even after controlling for push and pull factors as economic growth (GDP and firm growth) of and availability of jobs (firm/population, firm potential) in that region. What can also be observed

[2] For the estimation we used the Econometric Toolbox for Matlab by J.P. LeSage. http://www.spatial-econometrics.com

[3] A negative elasticity for the accessibility indicators can be interpreted as enhancing economic activity as the average travel times to all other regions will decrease.

is that there appear to be regional immigration clusters (ρ=0.002), as the literature on migration would suggest.

Table 4: Estimation Results for EAR Model Elasticities

	4.1.1.1 Dependent Variable			
	GDP Growth	**Firm Growth**	**Employment Growth**	**Net Migration per population**
AI_1 - train accessibility far	-	-	-	0.008***
AI_2 - train accessibility near	-0.300 ***	-0.065 ***	-0.041***	-0.009***
AI_3 - frequency weighted train accessibility far	-	-	-	-0.003***
AI_4 - frequency weighted train accessibility near	-	-	-	-
AI_5 - volume weighted train accessibility far	-	-	-0.029***	-
AI_6 - volume weighted train accessibility near	-	-		-
AI_7 - road accessibility far	0.046 ***	-0.69 *	-	-
AI_8 - road accessibility near	-0.180 ***	0.074 *	0.087***	-
$gdp\text{-}g_{t-1}$	0.522 ***			0.070***
$firm\text{-}g_{t-1}$	-	-	0.226***	0.032***
W_2*net migration	-	-	-	0.182*
Firm/population	-	-	-	0.010**
Firm potential	-	-	-	0.001***
W_1* $gdp\text{-}g_{t-1}$	-	0.178 **	-	-
ρ	-	-	-	0.002***
R-sq.	0.32	0.42	0.40	0.72
Obs., Var	99, 12	99, 15	99, 15	99, 9
N.draws	150000	150000	150000	150000
N.omit	1500	1500	1500	1500

***,**,** denotes significance at the 1, 5, 10 % level
W_1: inverse train travel times, W_2: inverse train travel times to 6 nearest neighbors,
$gdp\text{-}g_{t-1}$ GDP growth, lagged one year, $firm\text{-}g_{t-1}$ firm growth

4.2 Simulation

The model above can be used to simulate the economic impact of a change in traveling times and frequencies on the individual regions as well as their aggregates. The initial effect will stem from and improvement of travel times which leads to an improvement of accessibility. The reduction in the accessibility indicator will then positively stimulate the economic activity in the regions affected and will lead to second round effects through space. Therefore a wide range of different scenarios can be simulated.

In the following section the model is applied to simulate the effects of the new Vienna central station (Zentralbahnhof Wien).

5 EVALUATION OF THE ZENTRALBAHNHOF WIEN

5.1 Improvement of Accessibility

The simulation scenario for Vienna central station is that the operation of the new railway station will lead to a significant improvement of travel times for a number of Austrian regions. Therefore the train accessibility indicators will be reduced. The travel times for the scenarios were provided by the OEBB, the baseline scenario being that the Vienna central station is not built.

As can be seen in figure 2, regions in upper and lower Austria along the West-East axis will mainly benefit from the installation and operation of Vienna central station. Furthermore, the districts in Lower Austria along the north-south axis as well as the more distant districts in Salzburg and Tyrol along the Western railway line will benefit.

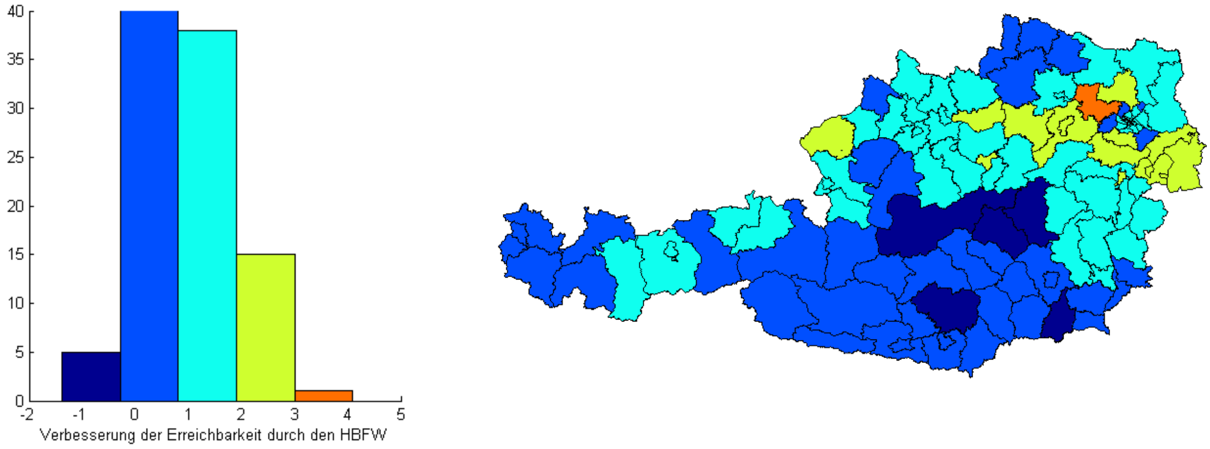

Figure 2: Improved accessibility through installation and operation of the Vienna central station, (Source: OEBB data, own calculations)

5.2 Impact on economic performance, firms, employment and migration

Figure 3 plots the impact on economic performance as measured by GDP. In analogy to the improvement of accessibility, the districts of lower Austria, Upper Austria, Salzburg and Tyrol will benefit most from the new central station. Along the north-south axis the districts in the south and the east of Austria will also experience favorable GDP developments.

Compared to the effects on economic performance, employment will benefit in similar areas as GDP. The main impact is to be expected in lower Austria, the northern Burgenland, Vienna and Upper Austria. It should be noted that in total employment will be boosted more than GDP.Figure 5 plots the effects of net migration after 30 years of operation of the Vienna central station. Vienna and the town of Salzburg will attract most of the new migration to Austrian districts, as they will benefit economically and in terms of accessibility the most. To a lesser degree also districts in Tyrol as well as Salzburg and Vorarlberg will benefit. In the east of Austria the current trend will continue and the migration to areas in the south of Vienna will increase additionally (compare figure 7 in the appendix). Not surprisingly: As the Zentralbahnhof will not change the accessibility indicators of Styrian regions growth and migration effects will not be observed for these regions.

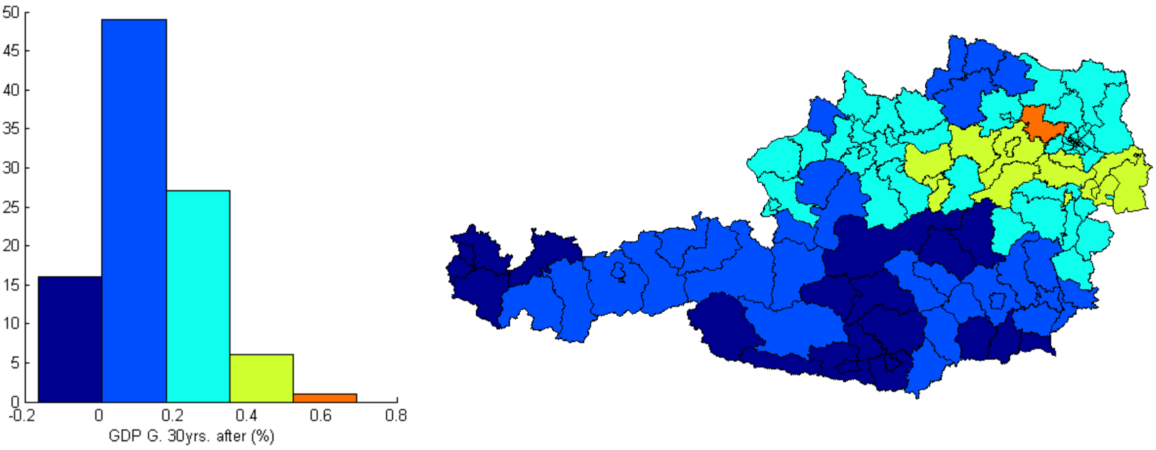

Figure 3: Regional GDP effects after 30 yrs. of operation, (Source: IHS EAR Calculations)

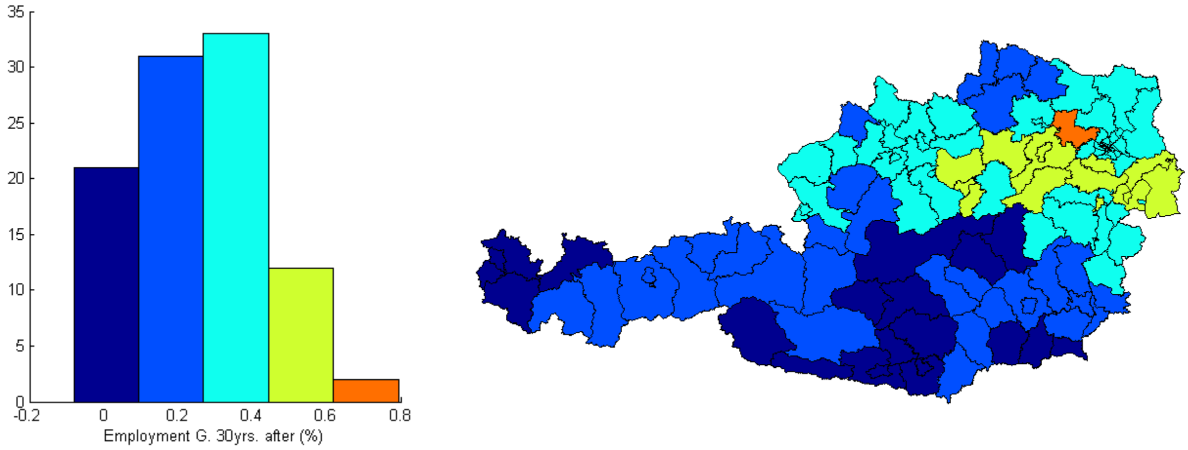

Figure 4: Regional employment effects after 30 yrs. of operation, (Source: IHS EAR Calculations.)

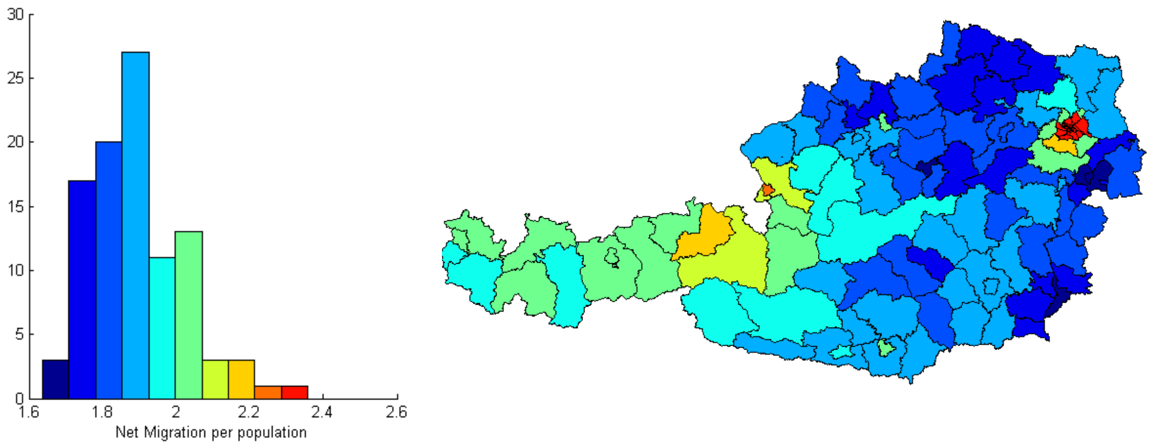

Figure 5: Net Migration per population effects after 30 yrs. of operation, (Source: IHS EAR Calculations)

Figure 6 draws the overall picture of the economic impact of Vienna central station. The three graphs in the first column display the GDP effects on a national level as well as the NUTS-2 level, which in Austria corresponds to the federal states (Bundesländer). In the operational stage the Vienna central station will increase Austrian GDP by 365 Mio. Euros, it will increase the number of firms in Austria by about 3,130 firms and will increase employment by about 6,800 people. As can be seen from these three graphs, most of the effects will materialize in the first 5-7 years.

The three bar charts in the second column display the distribution of these aggregate effects on the Bundesländer of Austria after 30 years. In terms of additions growth lower Austria, Vienna and the Burgenland will experience the main part of the positive effects. To a lesser degree Upper Austria, Salzburg and Tyrol will benefit.

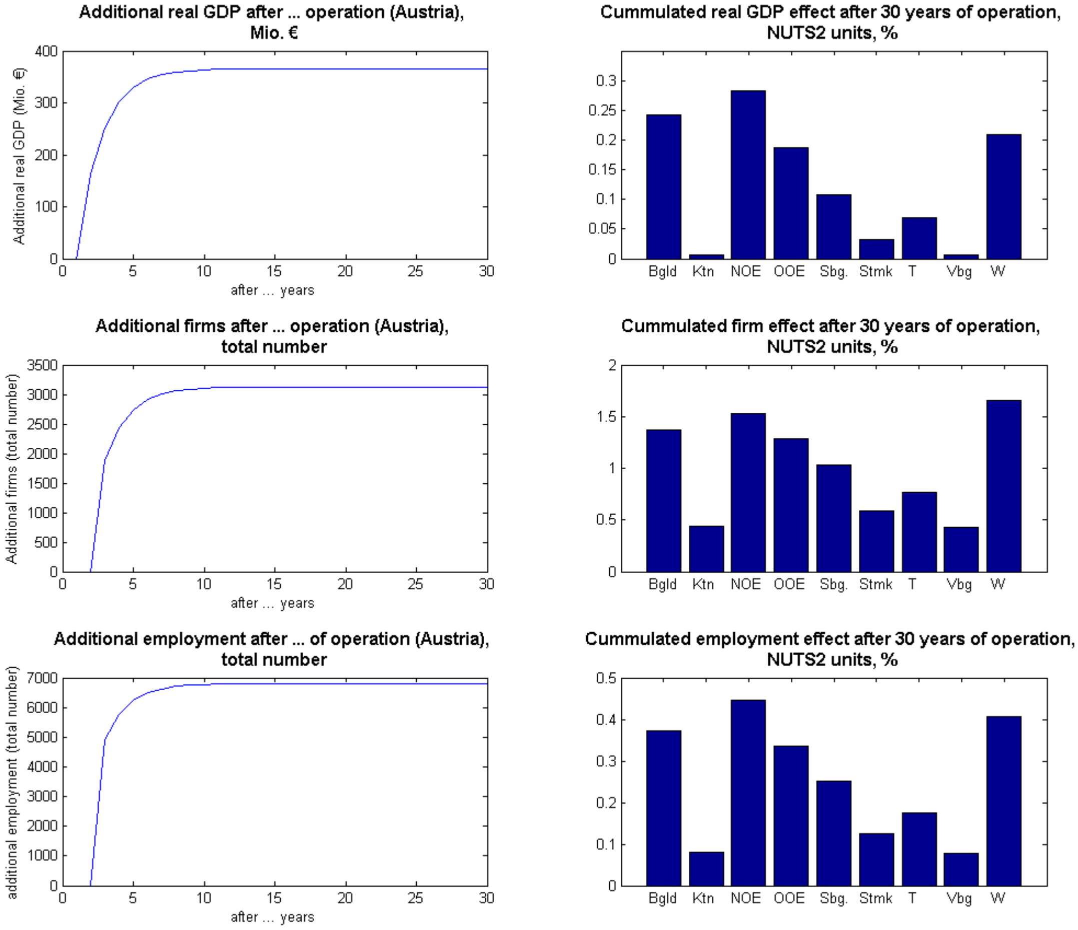

Figure 6: Summary of economic effects of Wien Zentralbahnhof, (Source: IHS EAR-model)

6 CONCLUSION

This paper demonstrates that a dynamic regional panel model can be used for long run forecasting on a regional level. We focus on the future economic changes that will come along with infrastructure improvements in Eastern Austria, when their accessibility effects translate directly and indirectly to higher economic activity. The latter effects are captured by the spatial econometric model. The results are summarized in maps that show the aggregated effects of the accessibility changes over 30 years.

That the main benefits of the Vienna central station can be found in Eastern Austria with its center Vienna, and the associated main traffic axis, which are east-west and north-south. The southern provinces Carinthia, East Tyrol and Styria will be not affected, except for the northern part of Styria and Burgenland, which traditionally have good traffic connection to Vienna. Also note that the adjustment process to a new level and distribution of economic activities will last about 5 years from the beginning of the operation of the Vienna central station.

From the simulation and forecast results we see that regions south and west of Vienna will benefit most in terms of increased GDP. Roughly summarized, the east-west axis along the Danube will be the major winner in term of GDP. The situation for regions along the north-south axis might change when the base tunnel in the Semmering region (Semmering Basis Tunnel) will be in operation and thus the south axis can be linked to the improved accessibility of the Vienna central station.

From the employment forecasts we see that the regional pattern follows quite closely the spatial pattern we have observed for the GDP effects.

Regarding net migration, we observe a bimodal pattern, with the clear winner being the center of Vienna on the one hand and the most western regions in Salzburg, Tyrol and Vorarlberg on the other hand. This increase in the western regions might not be a direct consequence of the Vienna central station, but reflects the improved overall accessibility in Austria together with the strong migration in the last decade in the western province. Again, circumstances for the western regions of Austria can be expected to change, should the Brenner base tunnel (Brenner Basis Tunnel) be built. Except for the city of Linz we see no direct influence for the regions in Upper Austria. The reason for this is that the city centers are already connected quite well, but more distant regions from the centers will not benefit.

Overall we see that the new techniques combining regional growth with traffic accessibility in a dynamic panel model are able to show interesting scenarios for the future. Further extensions of the model are possible, e.g. by focusing on the human capital effect of migration for instamce. Finally, this study has shown that improved traffic accessibility is a constant motor for regional growth in a modern economy.

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8 APPENDIX

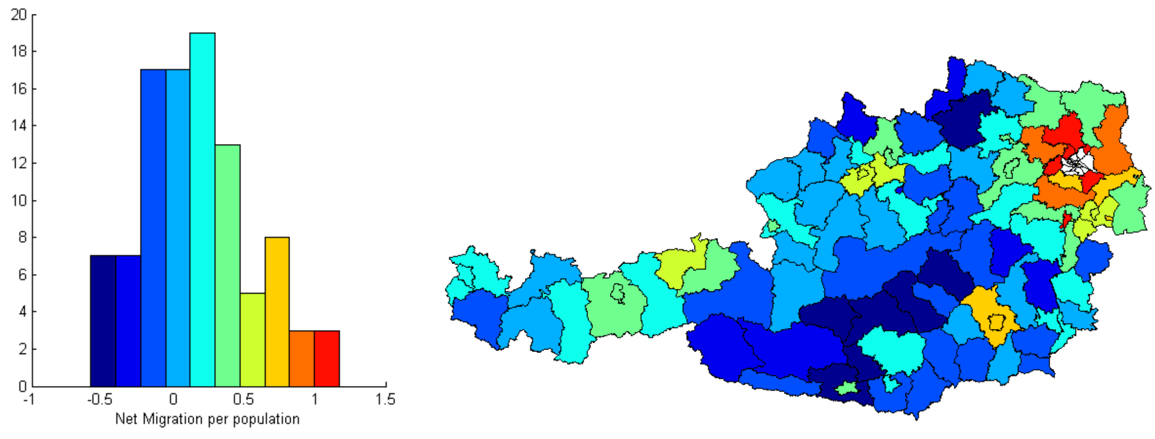

Figure 7: Net Migration per population, (Source: Statistik Austria, own calculations)