New Road Transport Infrastructure and Sectoral Regional Growth: A SCGE Analysis for the A4 extension to the Austrian-Hungarian border

Christoph Schmid[1], Karl W. Steininger[1,2†] and Alfried Braumann[3]

March 31, 2007

ABSTRACT: In mature economies new transport infrastructure (beyond bottle-neck elimination) is considered to hardly influence overall growth, but well so its spatial distribution and implied transport emissions. In a sectorally diversified spatial computable general equilibrium (SCGE) model of the Lower Austrian – Burgenland new highway (opened in 1991) to the now new member state Hungary, we analyse regional growth. Based on a GIS-approach we acknowledge both actual freight transport cost reduction by sector and interregional link and labour force accessibility change.

We find that freight transport cost reduction even for a small region does have negligible overall economic impacts. However, it is a few transport intensive sectors that show substantial impact in interregional trading prices and regional output. In particular our findings point out, that locally specific sectoral shares in production, freight transport cost shares, and – most of all – accessibility determine the order of magnitude of regional economic impact and transport emission consequences.

KEYWORDS: spatial planning, spatial CGE, empirical new economic geography, production and consumption location modelling, transport emissions

JEL: C68, D58, R12, R40

ACKNOWLEDGMENT: This research was supported by the Research Fund of the Austrian National Bank (Grant 11502); the authors thank for this funds financing enabling the present work. The authors also thank Birgit Friedl, Laurent Franckx, Olivia Koland and Gerold Zakarias for inspiring discussions and helpful comments. We especially point out the collaboration in access potential research with Stefan Schönfelder.

[1] Wegener Center for Climate and Global Change, University of Graz, Leechgasse 25, A-8010 Graz, Austria

[2] Department of Economics, University of Graz, Universitaetsstr. 15, A-8010 Graz

[†] corresponding author: Karl W. Steininger (phone +43 316 380 8441, fax +43 316 380 9830, e-mail: karl.steininger@uni-graz.at).

[3] Trafico Verkehrsplanung, Filigradergasse 6/2, A-1060 Vienna

1 INTRODUCTION

Substantial increases in transport infrastructure supply and transport flows in many countries over the last decades, both in freight and passenger transport, have enabled crucial growth in consumer benefits. But, as a recent OECD (2000, 13-15) report put it, "there have been costs – mostly environmental costs – that are eroding the benefits. […] The challenge for the 21st century is to maintain and even enhance transport's benefits while reducing its impacts to sustainable levels."

While transport services are crucial to economic activities, the transport sector in its current shape is connected to a range of substantial detrimental impacts. For example, mobility activities currently trigger the fastest increasing segment in fossil fuel emissions in many countries. In Austria, for example, while total greenhouse gas emissions increased by 18.1% between 1990 and 2005, emissions from road transport increased by 91.3% over this period. If Austria is to comply with its commitments within the European Union with respect to the Kyoto agreement, effective measures need to be prepared and implemented in due time. Similar demands for transport reorganisation arise from current noise and health impacts (e.g. respiratory illnesses triggered by particulate matter emitted or recirculated by transport).

In the set of instruments to govern environmental impacts of transport, both volume and mode, policy discussion focuses most often on the "narrow" transport sector, both on technological and management instruments. Long-term impacts on transport emissions, however, are much stronger governed by the way transport interacts within the broader social and economic system. In particular land use patterns, and transport infrastructure interacting with them, determine transport emission patterns for decades. In this paper we thus focus on the interaction of new transport infrastructure and land use patterns.

Choices in land-use and in transport are mutually dependent. Any given pattern of activity location induces a specific trip pattern, and, reversely, the location choice for each activity is dependent on the transport system and the opportunities it offers, since it is the transport system which defines the cost associated with all future activities at any specific location.

Most modelling has chosen one of the above approaches of primary causation. Only few efforts at integration have been made, e.g. Martinez (2000). The developments within new economic geography, triggered by Krugman (1991; 1995), however, have provided a number of new theoretical modelling devices and possibilities for simulation which need to be employed in suitable areas of empirical application beyond illustrative modelling (probably best presented in the work of Krugman himself).

We will proceed as follows. In section 2 the methodological device used, spatial computable general equilibrium modelling (SCGE), is argued for. Section 3 discusses the interaction between new transport infrastructure, economic growth and environmental quality. Section 4 presents the model and its implementation for an Austrian region. Simulation results depicting the freight cost change due to new infrastructure in this region within an imperfect competition setting are presented in section 5, impacts due to the change in labour force accessibility in section 6. A final section concludes by summarising the main results.

2 SPATIAL COMPUTABLE GENERAL EQUILIBRIUM MODELING

For modelling the interlinkage of land-use and transport, spatial computable general equilibrium (SCGE) models serve as basic starting point, as they

(i) inherently depict the simultaneous decision on both producer-producer and producer-customer distances, output levels, and structure and level of production input demands, each of which by sector.
(ii) inherently acknowledge transport costs (fixed and variable components), varying across locations
(iii) inherently depict production cost dependency on output levels (variable returns to scale)
(iv) respect budget constraints in the consumer, public and firm sectors
(v) include an initial spatial allocation of households (and thus spatial distribution of both labour and consumption potential), which is necessary to fix – in combination with explicit transport cost modelling – an efficient spatial distribution of production (without transport costs in models of variable returns to scale we can conclude that certain agglomerations will occur, but their location would be ambiguous, as we know from stylised models)

Implementing the monopolistic competition models of the Dixit-Stiglitz (1977) type into multi-region CGE-models, the few empirical examples of SCGE models available so far start from one of two ends: broad regional coverage with few economic sectors (Bröcker, 1998); or from a fully fledged sectoral structure, with regional diversity restricted to within a single country (Knaap et al., 2001; or in a later state of progress of the same model Tavasszy et al., 2003). In both cases the transport cost component is exogenously given by (separate) companion-models. The future issue, therefore, which the current paper is seeking to contribute to, is to transfer transport cost to an inherently endogenous variable.

The CGE approach lends itself to transport analysis because of its focus on

- the long term
- the analysis of substantial policy changes with economy-wide feedback effects
- the analysis of pricing instruments

The extension of the long tradition in CGE to spatial CGE modeling for transport analysis involves two core issues to be solved

- the identification of transport costs by sector
- the specification of the type of transport costs

In supplying methods to solve these problems this paper is meant to contribute to also empirically overcome the basic neglect of spatial aspects we found in mainstream economics prior to 1990 even on the theoretical side, that for Blaug (1985, 629) “remains one of the great puzzles about the historical development of economics”.

3 TRANSPORT INFRASTRUCTURE AND ECONOMIC GROWTH

GDP and transport volumes have generally developed in parallel in the past. This has been true for both developing and developed economies. Over the last two decades passenger transport (in terms of passenger-km) in Austria has grown at a rate slightly higher than income (GDP), freight transport (in terms of tonne-km) roughly at the same rate as output. Looking at this in slightly more detail, we find a roughly constant number of trips for passenger transport and a roughly constant time budget for travelling, but a significant increase in trip distance. In freight transport we find on the one hand that goods are transported further as market areas have grown in order to exploit economies of scale, but that the average weight of goods has declined, with the latter basically just offsetting the former in terms of transport service (tonne-km).

This observation of parallel growth of GDP and transport in combination with the “strong belief among decision makers, transportation planners and economists, that transportation plays a vital role in enhancing economic growth” often leads to the conclusion that enabling growth in transportation unambiguously fosters economic growth, or even is a necessary prerequisite for it. Such a conclusion is, however, likely to be far too premature. Improvements in transportation can indeed improve productivity of labour and capital and thus enhance growth – but whether this is the case in any particular situation is a matter requiring much closer inspection (see below). The observation of parallel growth alone of course also does not reveal the direction of causality. Do increased transport volumes (and a growth in transport infrastructure) trigger economic growth, or does economic growth lead to a higher demand for and supply of transport? If the latter was true in the past, transport growth may still not need to be a necessary consequence of economic growth in the future.

To answer these questions let us look at historical experience first. The importance of transport and transport innovations for economic growth has been analysed for different transport systems focusing on different centuries. The result of many studies in this vein is that economic growth that has normally been attributed to a particular form of transport development has in fact generally had many sources. For example, de Vries (1981) looked at the economic impact of the development of the horse drawn barge and the canal network in the Netherlands, foremost in the 17th century. In spite of a tremendous growth in the canal network during this period, the author concluded that it may only have affected the level of economic performance at some locations, but not the overall rate of economic growth. Similarly, Fogel (1964), in his study on the impact of railroad development on American growth in the 19th century found that there was a multiplicity of innovations responsible for growth, and railroad development only shaped economic growth in a particular direction, but was not the prerequisite for it. There are more affirmative historical references in the literature indicating the relevance of transport investments for economic growth, which are then often directly contradicted by more critical research. In an overall evaluation Berechman (2002), for example, judges that as "[a] review of historical studies shows, it is difficult to conclude explicitly that transportation development necessarily induces economic growth even when the economy is in the developing stage."

When analysing the present situation many authors point out the importance of looking at the specific characteristics of the transport investment before concluding that transport development has a positive impact on economic growth. For example, there is the need to take account of the impact of different stages of economic development (advanced or low-income economy). Next, peculiarities of the project are crucial, such as whether the investment involves an elimination of a network bottleneck or simply an addition to capacity. Further, we need to consider the structure of the market of transport-using industries, in particular the prevailing degree of competition. When transport improvements lead to more intense competition, their potential contribution to growth is more relevant.

With respect to advanced economies, several major changes have been pointed out that make their growth less susceptible to transportation improvements. Berechman (2002) lists five of these: (a) a decline in the share of work related trips – transport improvements thus benefit leisure activity rather than labour productivity; (b) employment patterns become spatially more dispersed, making, for example, cross-commuting more important than commuting to city centres, resulting in fewer clear candidates for commuting transport improvements; (c) in postindustrial society the main source of profits and power has become knowledge and information, most of which is unrelated to transportation; (d) the proportion of the elderly in the population is constantly rising, and their use of transport is mostly for non-work trips and at off-peak hours; (e) narrowing limits of land resources and environmental uptake capacities require that transport systems become less resource intensive and thus allow for economic growth to be decoupled from transport growth.

We shall next develop a spatial CGE model to quantify the growth effect for a particular region and particular infrastructure project.

4 THE SPATIAL CGE MODEL

4.1 PRODUCTION AND FOREIGN TRADE

There are two types of commodities produced in each region, goods produced for domestic markets and goods produced for export. In an Armington style modelling these goods are assumed to be imperfect substitutes produced as joint products with a constant elasticity of transformation. For output D_{ir} used domestically and exports X_{ir}, total production Y_{ir} in region r for sector i is

$$Y_{ir} = \left[\alpha_{ir}^{Y} D_{ir}^{1+1/\eta} + \beta_{ir}^{Y} X_{ir}^{1+1/\eta}\right]^{1/(1+1/\eta)} \tag{1}$$

Inputs to production include primary factors labour L and capital K, as well as intermediate inputs (domestic and imported). Intermediate inputs are proportional to the activity level of the sector.

Intermediate demand ID_{ir} is a composite good of domestic intermediates DI and imported intermediate demand M

$$ID_{ir} = \left[\alpha_{ir}^{I} DI_{ir}^{\rho} + \beta_{ir}^{I} M_{ir}^{\rho}\right]^{1/\rho} \tag{2}$$

4.2 TRANSPORT

Transport costs are only acknowledged in interregional transport. Real transport costs T_{irs} in sector i are assumed proportional to bilateral trade flows between regions r and s

$$T_{irs} = \tau_{irs} M_{irs} \tag{3}$$

whereby transport services are supplied by the exporting region.

4.3 FACTORS OF PRODUCTION AND INCREASING RETURNS TO SCALE

The primary factors of production, capital and labour, are taken as region-specific supply, not mobile to migrate.

Following the approach of Dixit and Stiglitz (1977), production is characterised by monopolistic competition: an endogenous variety of n goods is produced in either region r and sector i. Different varieties of goods are imperfect substitutes in consumption. Each firm acts as a monopolist on its output market, taking the actions of the other firms as given. Again, imperfect competition arises due to the assumption of internal economies of scale at the level of the individual firm and the consideration of transport costs.

Based on empirical data for the regional structure presented below, production in either region and sector involves different marginal input requirements of labour *m* and capital and different fixed factor requirements *F*, independently of the quantity manufactured and assumed to comprise labour only: $l = F + m \cdot x$, where *l* is the labour required to produce any output *x*. Then, the production of a quantity *x* of any variety *i* in region *r*, with production coefficients *γ* and *δ*, involves

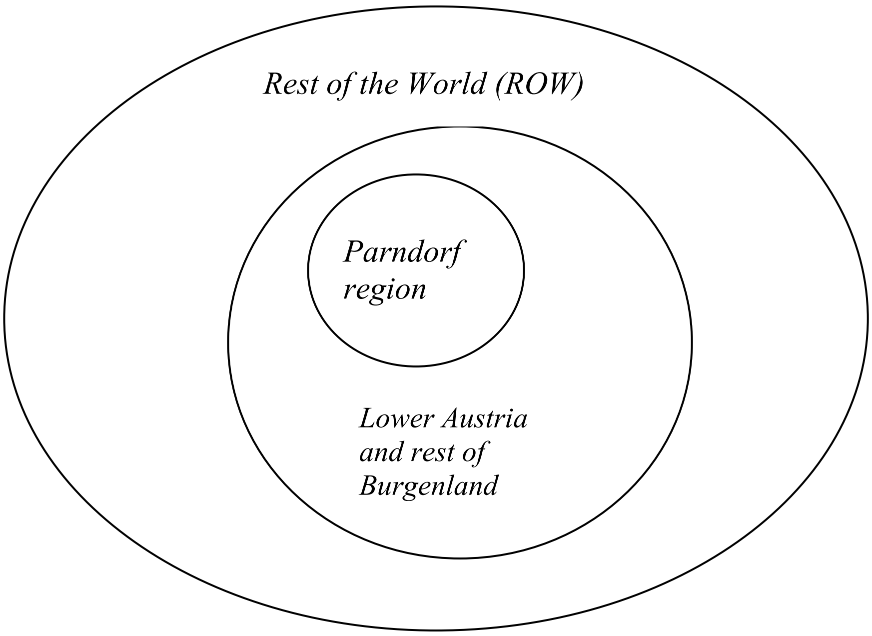
$$x_{r,i} = l^{\gamma_r} \cdot k^{\delta_r} \qquad \text{with } \gamma_r + \delta_r > 1 \tag{4}$$

inducing each firm to produce exactly one variety. Internal scale economies at the level of the individual firm and agglomeration externalities, accordingly, explain where production is located. More specifically, forward and backward linkages create an incentive for workers to be close to the production of consumer goods.

4.4 IMPLEMENTATION

A three-region model is implemented, focusing on the region of core analysis, Parndorf (*region 1*), close to the Austrian south-eastern border, a surrounding region (the remaining of the provinces of Lower Austria and Burgenland, also referred to as *region 2*) and ROW (rest of Austria and abroad), see Figure 1.

Figure 1: Regional Structure



The model presented above has been implemented within GAMS (Brooke et al., 1998) using the modelling framework MPSGE (Rutherford, 1998) and the solution algorithm PATH (Dirkse and Ferris, 1995) in its – with Todd Munson – expanded version 5.6.04.

Using a three-regional split up of economic data of the provinces of Lower Austria and Burgenland, derived by using the provincial input output structure of these provinces, the focus region of Parndorf has been islolated.

Based on a sectorally diversified trade flow matrix of Austrian political districts by political district Pichler and Schaffer (2006) derived the freight cost reduction by sector and interregional link due to the opening of the new highway in the following way. The costs for a certain route are calculated with ArcGIS that gets input data from a software based on Matlab and Access. The route calculation is based upon minimizing the variable costs, these are composed by the variable costs per kilometer (primarily fuel costs and variable depreciation of the equipment) and per hour (wage costs of the truck driver). The fixed costs are given in €/km and based on the assumption, that the truck is in use 240 day a year and makes 600-700 km per day.[4] The fixed costs are added to the variable costs provided by ArcGIS after the optimization. All the networks were calculated with an unique combination of a semi trailer truck for medium distances and a simple 40” trailer for containers[5].

We find that the actual transport cost reduction due to the opening of the A4 motorway extension in 1991 strongly diverges across sectors. Transport costs change substantially for agricultural goods and for food, and can be reasonably assumed to homogenously change only for the remaining sectors of the economy.

Table 1 presents the freight cost reduction due to A4 motorway opening by sector and interregional link.

[4] We assumed that the trucks are employed mainly in the regional transport for about 16 hours a day. Three hours are used for loading and unloading and breaks. Due to the high share of urban areas (Vienna, Wr. Neustadt, St Pölten) and municipal area (tempolimits between 30 and 50 km/h) in the regions under investigation, we set the average speed of the trucks to only 55 km/h.

[5] This may seem inappropriate for several branches that are known for using special trailers – especially the building industry and the timber industry, but the costs for a trailer for logwood or for building material don’t differ essentially from those of a standard trailer for containers. Additionally we’d need the split of designs of the equipment for each sector.

Table 1: Most significant freight transport cost reduction by sector and by interregional trade link

exports from region and sector	to region Parndorf	Lower Austria/ Burgenland	ROW
	[% of total interregional trade expenses]		
Parndorf			
Agriculture		11.24	4.06
Food		8.12	2.33
Other Industry		6.32	2.85
Lower Austria/ Burgenland			
Agriculture	8.76		
Food	3.68		
Other Industry	7.11		
ROW			
Agriculture	8.11		
Food	5.11		
Other Industrie	8.21		

We calibrate the model to the 2001 data set, including the 2001 reference split up of production in the three regions and interregional trade flows. Interregional trade balances are taken as fixed for the simulation scenarios. Increasing returns to scale are assumed to be present in all but one sector, the latter being “other industries”. This supplies us with a reference case for industries closer to the perfect competition assumption.

5 SIMULATION RESULTS WITH OBSERVED FREIGHT TRANSPORT COST SHARES AND REDUCTIONS

Our interest is in the spatial structure of growth, triggered by new infrastructure supply. Our first simulation thus introduces a reduction in interregional freight transport costs by a new infrastructure available to the core region of analysis, Parndorf. Pichler and Schaffer (2006) also supply the actual freight transport cost shares by sector for our model. The bilateral trade flows by sector and by political district (99 districts of origin by 99 districts of destination and by 24 NSTR goods, and foreign trade appropriately acknowledged) supply the relevant weights in this cost determination for the flows among the three regions as defined for our purpose.

Figures 2 and 3 report transport costs shares by sector and interregional trade link.

Figure 2: Transport cost shares region 1 to region 2, by sector

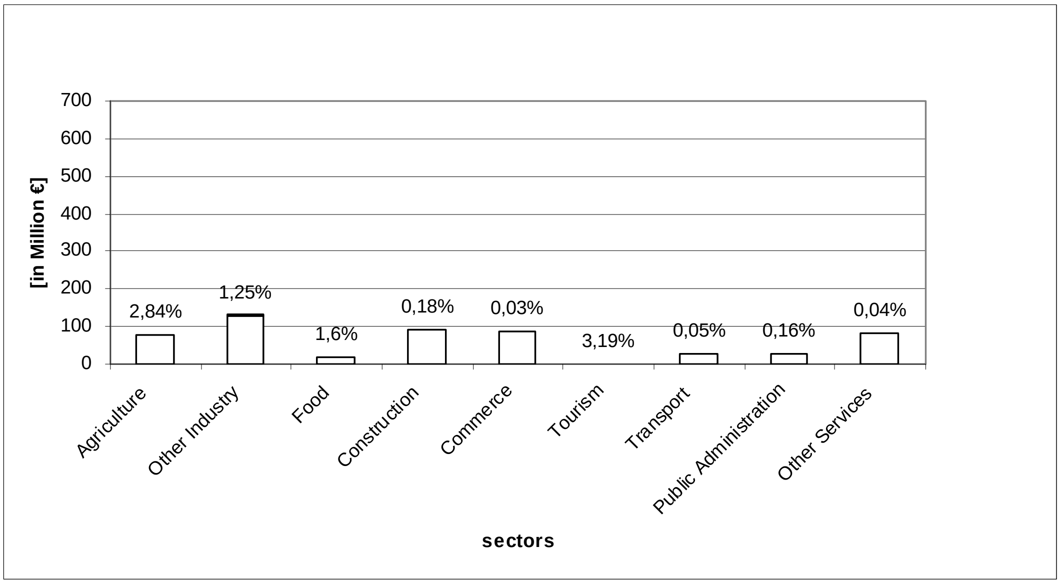
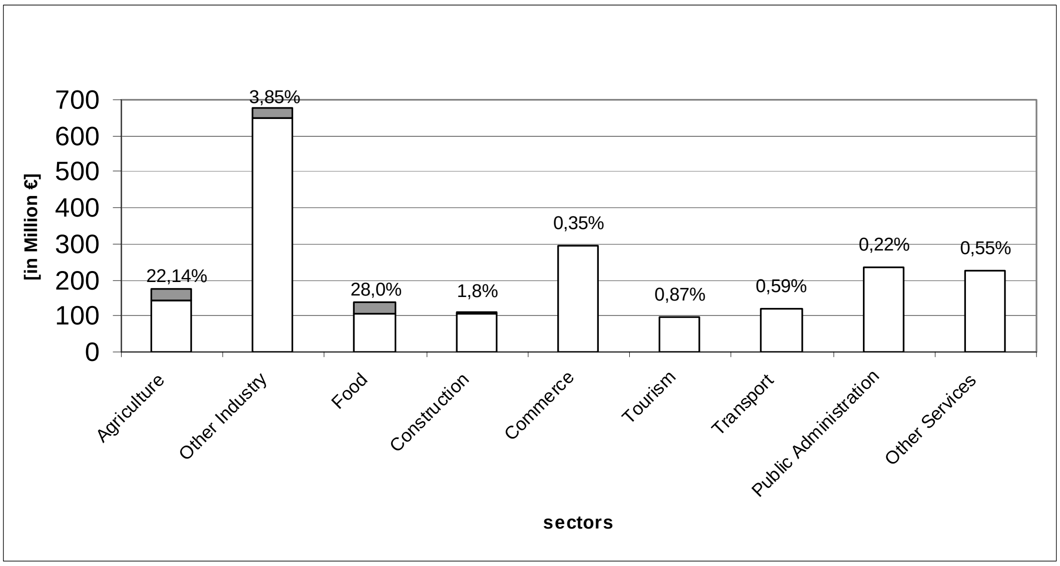


Figure 3: Transport cost shares region 1 to ROW region, by sector

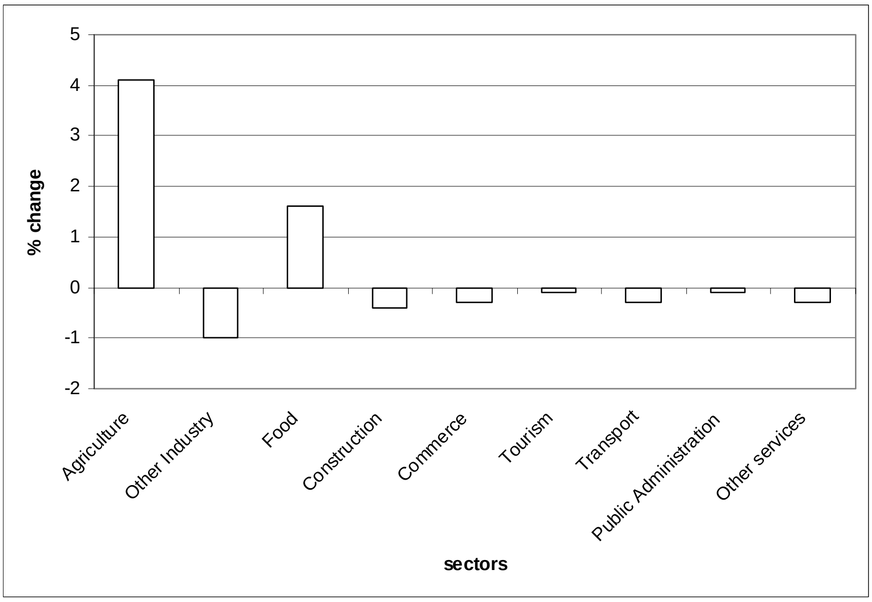


Using the model presented in section 4 with this empirically relevant freight transport cost data in terms of both cost shares and cost reductions due to the opening of motorway A4 we can exert an ex-post analysis to explore which quantitative economic development of regional redistribution of the past was due to this motorway opening.

We shock our 2001 reference case backward looking by a transport cost increase. For ease of interpretation we report results reversely, i.e. as impacts 1991-2001, thus in usual historical sequence. Transport cost reductions will thus increase output in sectors characterized by high export shares and initially high transport cost shares.

Our empirical analysis allows to quantify the dimension of interregional redistribution of economic activity by sector. Figure 4 reports simulation results of this analysis.

Figure 4: Sectoral Output Change due to A4 motorway opening, Parndorf region



We measure a welfare benefit connected to this new infrastructure for the Parndorf region due to freight transport cost reduction at 0.1% (Hicksian welfare index). The welfare benefit of this single infrastructure project to both region 2 and ROW are negligible.

6 SIMULATION RESULTS WITH OBSERVED CONSUMER ACCESSIBILITY IMPROVEMENT

However, freight transport cost reductions are not the only relevant impact to be acknowledged when new infrastructure, such as the A4 motorway, is considered. We also find high retailing investments in the Parndorf region, indicating that consumer access is a crucial parameter in the further economic development induced by new transport infrastructure.

The concept of accessibility potentials has its origin in the classical gravitation theory of physics and was adopted in a range of geographical studies since the 1940s (e.g. Stewart,1947 or Hansen, 1959). Gravity-based accessibility measures are still the most widely used general method for measuring spatial reach. Since its first applications, population potentials are the predominant focus of analysis. Thereby the potential of a given location is explained not only by its own endowment with a certain attribute, that is the population living in the location, but also by the endowment of location in the wider region, that is the population living outside the location yet still within a surmountable distance. In principle, the population is spatially weighted: Individuals living closer to the reference location contribute more to the location's accessibility potential than those further away. The assignment of these theoretical potentials to existing locations is called „potential mapping" (see Schumacher, n.a.).

Potential mapping is applied where a pattern of point related information is transformed into a continuous representation of space. In the literature, we find a variety of formulas to calculate potentials. For the present accessibility model, we assume that the accessibility potential of a location increases with the number of activities (i.e. the magnitude of supply) at the location itself and at all surrounding places. Furthermore, the contribution of a location towards the potential of the reference point decreases with increasing distance. Locations outside the scope of the analysis are not regarded due to their negligible effects on the location considered.

Potentials are theoretical indicators of the endowment of a location with regard to a certain attribute. Equally, the potential of a place may be considered as a field of attraction with its centre at the respective place. To better understand the potential approach, it may be described in several ways: First, it acts as an index of the nearness of attributes tied to a certain place to one another as well as a measure of the influence of people at a distance. Thereby the accessibility model is capable to represent the intensity of possible contact between people at location *i* and those at all other locations potentially accessible. Second, it may be seen as an indicator of relative position, i.e. as a measure of the accessibility of people in *i* to people in all parts of the area being examined.

6.1 THE ACCESSIBILITY MODEL

Accessibility potentials are calculated by a model consisting of two main components: an activity function and an impedence function. The activity function determines the attractiveness of any location considered to be contributing to the reference region’s accessibility potential. For our purpose, attributes are population, number of workplaces and regional income. The impedance function in turn defines how distance curbs the effects that the attributes exercise on the location considered. To take an example: The effects that the population of Bratislava exercises on the city of Vienna shall be higher than the effects of the population of similar-size, but further away Dresden. The impedance function may take varying forms, with the negative exponential form most frequently used in literature. We thus construct our indicators of accessibility following equation (5).

$$P_i = \sum_{j=1}^{n} A_j * e^{-\beta * t_{ij}} \qquad (5)$$

P_i potential at location *i*

A_i activities attributed to location *j* (population, workplaces, regional income)

β impedance factor

t_{ij} Travel time between locations *i* and *j*

The impedance factor β practically calibrates the sensitivity of activities to travel time. A very high β close to 1 represents a highly degressive distance decay which means that places further away from the reference point are highly devalued. This will be used for studies of phenomena with purely local impacts, where effects can be felt only over a very short distance. Shifting β closer to 0 results in an ever more linear impedance function, with a β of 0 meaning that distance does not affect the influence of the activity at all. Thus, activities with global dimensions or repercussions (e.g. production sites of intermediary products) call for a very low β, while activities with local repercussions (e.g. commuters) need a rather high β. Table 2 shows selected reference values from earlier studies. For our model which is applied to a location on the border of two metropolitan areas (i.e. Vienna and Bratislava), we chose a β of 0.05, which implies a half life period of 13min 54sec.

Table 2: Use of in β in earlier studies

Source	β	Activities covered
BAK (2005)	0.0011	Global accessibility of Zurich
BAK (2005)	0.0051	Continental accessibility of Zurich
Schürmann and Talaat (2000)	0.03	Accessibility of European Regions by Lorry
Schürmann and Talaat (2000)	0.07	Accessibility of European Regions by Car
Schumacher (n.a.)	0.25	Commuters in Saxony

6.2 ACCESSIBILITY CHANGE FOR THE PARNDORF REGION

Our model was applied to the region of Parndorf, a community of 3,218 inhabitants (2001) located in the Austrian Bundesland of Burgenland. After the political changes in Eastern Europe that resulted in the fall of the Iron Curtain in 1989, Parndorf has experienced a rapid development. The community managed to attract new housholds and companies, and furthermore a vibrant retailing market emerged which annually attracts several million shoppers from Austria and the bordering countries. Additionally, being situated approximately 30 km from the city limits of both Vienna and Bratislava, Parndorf is increasingly becoming subject to these cities' growing "urbanisational" pressure.

We calculated how accessibility potentials of Parndorf developed after 1988. Over the last 20 years, accessibility has mainly changed for two reasons: politics and road infrastructure extensions. Only shortly after the border between East (here: Hungary and the then CSSR) and West (here: Austria) became penetrable in 1989, a highway („A4") first linked Parndorf with Vienna in 1991. Three years later, the same highway was extended into Hungary. Then, in 2004, the now Slovak Republic and Hungary became members of the European Union with implications for an even easier commercial exchange. Scheduled for opening in 2007, a totally new highway („A6") will connect Parndorf with the Slovak Republic and thus the city of Bratislava. As final stage of the ongoing integration process, we assume the entry of Slovak Republic and Hungary to the Schengen Treaty to finally reduce border waiting times to zero. The entry will be probably in 2008.[6] Table 3 gives an overview of the different steps of development covered.

[6] Austrian Ministry of Foreign Affairs, July 2006.

Table 3: Changes of accessibility of Parndorf

Date	Type of change	Change	Effects of Travel time
1988	-	Initial situation	-
1989	Political	Border opens between East and West	Border waiting time reduced
1991	Infrastructure	A4 Vienna – Parndorf opened	Highway travel time reduced
1994	Infrastructure	A4 Parndorf – Hungary opened	Highway travel time reduced
2004	Political	EU-enlargement	Border waiting time reduced
2007	Infrastructure	A6 Parndorf – Bratislava opened	Highway travel time reduced
2008	Political	Entry Schengen Treaty	Border waiting time reduced to 0

The analysis included the whole of Austria, Hungary, the Slovak Republic and the Czech Republic. Thus every location within a travel distance of 120 minutes from Parndorf is covered. The first major agglomeration outside of these four countries would be Ljubliana (Slovenia) or Munich (Germany), both at a distance of approximately 200 minutes. With β of 0.05, these cities would be weighted by a factor of approximately $4{,}5*10^{-5}$ which renders them insignificant for the accessibility potential of Parndorf. In Austria, we used political districts as level of spatial aggregation. As for the other three countries, spatial aggregation was the same as used for the Austrian “Verkehrsprognose 2025+” project (Käfer et al., 2006). Here, it was organised along the lines of NUTS-III, yet in selected cases not wholly identical.

Summarizing the results specified in full detail in Braumann and Schönfelder (2006), we developed an indicator for accessibility improvement as given in Table 4.

Table 4: Change in accessibility for Parndorf region over two decades, 1988=100

	1988	1989	1991	1994	2004	2007	2008
Accessibility potential of population	100	120	160	173	205	221	295
Accessibility potential of work places	100	121	164	178	211	228	307

6.3 REGIONAL IMPACT OF ACCESSIBILITY CHANGE

With these results we are to determine their regional economic implications using our SCGE model as specified above. A doubling of the accessibility potential in our analysis is translated into a 5% increase of labour productivity (efficiency labour). We use the change in accessibility between 1989 and 2004 from table 4. Table 5 presents the results of this policy simulation.

Table 5: Regional economic impact due to accessibility increase after A4 motorway opening, Parndorf region, 1990-2004

Macroeconomic Variables	
[% change]	
Efficiency Wage	-0.8
Capital Price	0.8
Welfare	4.4

Sectoral Variables	Variety Index per sector [% change]
Agriculture	-1.3
Other Industry	1.3
Food	-0.8
Construction	0.8
Communication	0.6
Tourism	-0.1
Transport	0.6
Public Administration	0.5
Other Services	0.2

We thus find that the overall regional macroeconomic impact of the A4 opening is dominated by the accessibility effect. Regional welfare increases by 4.4%, while it increases only 0.1% due to freight transport cost reduction. For some particular freight transport cost intensive sectors, however, it is well the latter impact that dominates. For agriculture, for example, freight transport cost reduction induces a 4.1% output increase, while accessibility gains favours other sectors, thus exerting even a negative impact on agricultural output as a consequence of improved accessibility.

The activity level in the transport sector is rising by 0.6%, ceteris paribus inducing also a corresponding rise in transport emissions.

7 CONCLUSIONS

In this paper we started from the assertion that transport infrastructure in mature economies does not really have an impact on overall growth, but does have an impact on both the structure and level of the regional distribution of economic activity. We develop a three-region spatial computable general equilibrium with Dixit-Stiglitz imperfect competition production to test for this assertion empirically. Implementing the model to the Parndorf region in eastern Austria supplies us with a first quantitative result, indicating which sectors benefit from new transport infrastructure, which loose. We use this model to quantify the impacts of both freight transport cost reduction and accessibility increase for consumers (and labour) due to new transport infrastructure opening, using the example of the motorway A4.

We find that freight transport cost reduction even for a small region, such as our simulation was carried out for the core region of two political districts, does have negligible overall economic impacts. However, it is a few transport intensive

sectors that show substantial impact in interregional trading prices and regional output.
For the implications of accessibility increase, the regional economic impacts are quite larger. For the A4 motorway opening, for example, we find a welfare increase for the core region at the order of magnitude of 4%. The causation here runs via both lower efficiency wages and increased consumer demand due to lower prices.
Overall, we thus do find a confirmation of the dominating view in the literature, that new transport infrastructure in mature economies hardly increases overall economic output, but may have a significant impact on its regional distribution. In particular our findings point out, that locally specific sectoral shares in production, freight transport cost shares, and – most of all – accessibility determine the order of magnitude of regional economic impact and consequently transport volume and emissions.

REFERENCES

Berechman, J. (2002)
Transport investment and economic development: is there a link?, in European Conference of Ministers of Transport (ECMT) (ed.), *Round Table 119: Transport and Economic Development*. ECMT, Paris, 103-138.

Blaug, M. (1985)
Economic Theory in Retrospect. 4th Edition. Cambridge University Press, Cambridge.

Braumann, A., Schönfelder, S. (2006)
Approaches to Introduce Accessibility Potentials into CGE Models, in: Koland, O. and Steininger, K.W. (eds.), *Spatial Dynamic Development and Environmental Sustainability*, Final Report to the Science Fund of the Austrian National Bank, Project No. 11502, WegCenter Report 13-2006, ISBN 3-9502308-0-7, Graz.

Bröcker, J. (1998)
Operational Spatial Computable General Equilibrium Modelling. *The Annals of Regional Science* 32: 367-387.

Brooke, A., Kendrick, D., Meeraus, A., Raman, R. (1998)
GAMS A User´s Guide. GAMS Development Corporation, Washington D.C.

De Vries, J. (1981)
Barges and Capitalism: Passenger transportation in the Dutch economy, 1632-1839. HES Publishers, Utrecht.

Dirkse, S.P., Ferris, M.C. (1995)

The PATH Solver, A Non-Momotone Stabilization SCHEME for Mixed Complementarity Problems. *Optimization Methods and Software* 5/1995: 123-156.

Dixit, A.K., Stiglitz, J.E. (1977)
Monopolistic competition and optimum product diversity. *American Economic Review* 67: 297-308.

Fujita, M., Krugman, P.R., Venables, A.J. (1999)
The Spatial Economy: Cities, Regions, and International Trade. MIT Press, Cambridge, Mass.

Fogel, R.W. (1964)
Railroads and American Growth: Essays in Econometric History, Baltimore: Johns Hopkins Press.

Hansen, W. (1959)
How accessibility shapes land use. *Journal of the American Institute of Planners* 25 (2): 73-76.

Käfer, A., Steininger, K.W., Axhausen, K.W., Burian, E., Clees, L., Fritz, O., Gebetsroither, B., Grubits, C., Koch, H., Kurzmann, R., Mayerhofer, P., Molitor, R., Ortis, G., Palme, G., Pehersdorfer, H., Pfeiler, D., Schönfelder, S., Siller, K., Streicher, G., Thaller, O., Wiederin, S., Zakarias, G. (2006)
Verkehrsprognose Österreich 2025+. Study of behalf of BMVIT, Asfinag, ÖBB. Schig, Vienna.

Knaap, T., Oosterhaven, J., Tavasszy, L. (2001)
On the Development of Raem: The Dutch Spatial General Equilibrium Model and It's First Application to a New Railway Link, mimeo/ERSA conference paper, University of Groningen.

Krugman, P.R. (1991)
Increasing returns and economic geography. *Journal of Political Economy* 99: 483-499.

Krugman, P.R.(1995)
Development, Geography and Economic Theory. Cambridge: MIT Press.

Martinez, F.J. (2000)
Towards a Land-Use and Transport Interaction Framework, in Hensher, D.A. and K.J. Button (eds.) *Handbook of Transport Modelling*. Amsterdam: Pergamon, 145-164.

OECD (2000)
EST! Environmentally Sustainable Transport. Synthesis Report. Paris: OECD.

Pichler, H., Schaffer, E. (2006)

A Method to Calculate Regional Freight Transport Costs with New Infrastructure, in: Koland, O. and Steininger, K.W. (eds.), *Spatial Dynamic Development and Environmental Sustainability*, Final Report to the Science Fund of the Austrian National Bank, Project No. 11502, WegCenter Report 13-2006, ISBN 3-9502308-0-7, Graz.

Rutherford, T.R. (1998)
Economic Equilibrium Modeling with GAMS. An Introduction to GAMS/MCP and GAMS/MPSGE. Economics Working Paper. University of Colorado, Boulder.

Schumacher U. (n.a.)
Potential mapping – ein geographischer Ansatz mit multidisziplinären Anwendungsmöglichkeiten.
http://www.sbg.ac.at/geo/agit/papers95/uschuh.htm (10/2006)

Schürmann, C., Talaat, A. (2000)
Towards a European Peripherality Index - User-Manual.
http://www.raumplanung.uni-dortmund.de/irpud/pro/peri/ber52.pdf (10/2006)

Steininger, K.W. (2001)
International Trade and Transport. Spatial Structure and Environmental Quality in a Global Economy. Edward Elgar, Cheltenham.

Stewart, J.Q. (1947)
Suggested principles of social physics. *Science*106: 179-180.

Tavasszy, L.A., Thissen, M.J.P.M., Muskens, A.C., Ooserthaven, J. (2003)
Pitfalls and Solutions in the Application of Spatial General Equilibrium Models for Transport Appraisal. mimeo, University of Groningen, Groningen.

Vickerman, R. (2002)
Transport and economic development, in European Conference of Ministers of Transport (ECMT) (ed.), *Round Table 119: Transport and Economic Development*. ECMT, Paris, 139-177.