A Regional Dynamic Input-Output Model of Tourism Development in the Light of Climate Change

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1 Introduction

The development of tourism demand in the German coastal regions will be influenced by climate change in the coming decades. Rising temperatures, changing weather conditions, sea level rise, invasive species, water quality and algae blooms might affect tourism demand positively or negatively – with correspondent consequences on the regional economy. The research project "Regional Adaptation Strategies for the German Baltic Sea Coast (RADOST)" investigates the effects of climate change in the north-eastern German coastal region of Schleswig-Holstein and Mecklenburg-Western Pomerania from an interdisciplinary perspective.[1]

The work presented here is part of the socioeconomic analysis that is carried out within the RADOST project. It has been the starting point of developing a dynamic regionalized Input-Output (IO) model that is used to assess the effects of climate change and adaptation strategies on the regional economy. In a first step the model has been set up for the tourist sector in Mecklenburg-Western Pomerania. The possible developments of the tourism demand – influenced by climate change and other factors – were represented in three scenarios, which in turn were used as input data for the IO model (see Section 4.3).

Since the first proposal of a (linear) dynamic IO model in Leontief (1953), dynamic IO theory continued in various directions. One branch of literature continued with the linear dynamic IO models, following the proposal of Leontief (1953). However, soon it was found, that the empirical counterpart of the matrix of capital coefficients **B** is singular, and the model is instable or does not have a numerical solution, see Sargan (1958) and Leontief (1961). There have been various attempts to cure instability by introducing gestation lags in investment and by taking a discrete form instead of continuous time, however, the instability problem could not be solved, see Fleissner (1990). Blanc and Ramos (2002) reinterpreted the linear dynamic model. Assuming that the dynamic model yields a steady state in the sense that output does not change from time to time, they require **B** to either be zero or to have negative entries. They re-interpret **B** as a

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1 For detailed information on the RADOST project see: www.klimzug-radost.de

countercyclical policy leading to the long term equilibrium (Lian 2006). The re-interpretation of the capital coefficients' matrix was adopted by Lian (2006) construct a linear dynamic IO with an inoperability-IO model.

There are however, also other approaches to incorporate dynamics and IO models than linear systems. Among them are planning models that use static IO to solve each period's balance of goods and which introduce some kind of stock variable (see for example Ryaboshly 2006; Lovell 1992). Next to these, there are dynamic models which build a bridge to CGE modeling, by introducing nested production functions with partial factor substitutability. This of course supposes the determination of prices and wages (see for example Zhang 2008). As the IO models with CGE-elements can be closed, so can be models that describe the non-production elements by econometric relations (see West 1995).

Last but not least, another strand of literature develops a kind of non-linear IO models, where the supply side is modeled by static IO and some or all elements of demand are determined via decision functions within the model. Duchin, Szyld (1985) developed a model with endogenous determination of capacity adjustment, which was deepened by Kalmbach, Kurz (1990) and Edler, Ribakova (1993). This last type of dynamic IO model will be the basis of the present analysis, to be found below. It was employed for a number of reasons. First, it explicitly accounts for capital stock adjustment (investment and disinvestment) which the authors considered to be important due to the time span the simulation is to cover. Second, it shows stable computation outcomes (see the linear dynamic model in contrast). And third, the analysis centered around a future development driven by exogenous factors, here scenarios on future tourism demand. Last, but not least, it is a rather simple model among the non-linear dynamic IO models and does not require as much data as other models.

2 Model

In order to estimate the output effect of tourism development scenarios in Mecklenburg-Western Pomerania a dynamic, non-linear Leontief-Szyld-Duchin model (LSD-model) was employed. It builds on the work done by Edler, Ribakova (1993) and Duchin, Szyld (1985).

It is an iterative non-linear open IO model with exogenous final demand. There exists a capital stock in each sector expressed in potential output (henceforth capacity). Capacity and actual output are interrelated via a number of decision functions determining the adjustment of capacity to keep track of the development of output. Capacity expansion constitutes the second part of demand, i. e. investment into the typical capital stock goods necessary to produce a specific quantity of some type of goods. There is free disposal, i. e. scrapping of capacity does not inducing demand.

In Duchin, Szyld (1985), desired future capacity $c^*(t+\tau)$ is planned to expand by the rate of past output growth or a maximum rate of $1+\delta$. However, in a second decision function actual capacity expansion is not allowed to be negative, meaning that capacity cannot be reduced. The flexible accelerator distributes the capacity expansion plan for the year $t+\tau$ over several periods. The sum of all shares of different year's expansion plans to be realized in a specific period are then summed up and multiplied with $(\mathbf{t}) = [b_{ij}]$, the matrix of capital coefficients in period *t*. These denote capital stock of type *i* used per production of good *j*.

Edler, Ribakova (1993) added the possibility for capacity to also decrease while maintaining positive computation results for "output", in contrast to the earlier developed linear dynamic IO models. They state that such as growth of output should be a guide line for the growth of capacity, (persistent) underutilization of capacity should eventually lead to the dismantling of capacity (conf. ibid., 282). The effort of Edler, Ribakova (1993) was motivated by the observation of a bias towards an overestimation of output caused by capital stock (or capacity) maintenance costs in ex-post simulations with the LSD-model (without the possibility of a shrinking capacity) and an underestimation of capacity expansion (ibid., 280).

The model employed here can be described as follows. It solves iteratively and is not a planning model but merely has its dynamics in the connection between backward[2] looking investment decisions determining future capacity adaptation. In each period the goods balance is solved, where output $\mathbf{x}(\mathbf{t}) = [x_1, \dots, x_n]^T$ depends on demand.

To determine the endogenous part of demand a number of steps are necessary. First, desired capacity $c_i^*(t+\tau)$ is calculated depending on installed capacity $c_i(t)$ and the minimum out of weighted past output growth and $1+\delta$.[3] The other side of the coin is reducing capacity as output falls. This is supposed to happen when capacity has not been used for certain time span (Ψ periods). To that end, unused capacity $\alpha_i(t)$ is determined for all preceding periods, depending on a benchmark rate of utilization $\hat{\beta}$ and output $x_i(t)$. As the model proceeds in time, $\alpha_i(t-1) \dots \alpha_i(t-\Psi)$ have to be updated considering reductions in capacity that took place between $t-1$ and $t-\Psi$. The minimum of all $\bar{\alpha}_{i,t-\psi}(t-1)$ is declared idle capacity, $d_i(t)$, since it is that part of the production capacity which has not been used over Ψ periods.

2 Endogenous capacity adjustments depends on average capacity utilization over the past σ periods (years), the "stock" of unused capacity over the past ψ periods and output growth over the last two periods.

3 *Edler, Ribakova* (1993) multiply the respective growth rate by $x_i(t-1)$ to get desired future capacity $c_i^*(t+\tau)$. In the present study it has proved to cause severe instability in computations. That is partly due to the unbalanced demand vector which was employed, where some sectors do not face consumer demand and just depend on the growth of the production capacity of other sectors. So $x_i(t-1)$ was replaced by $c_i^*(t)$ to fix instability problems. This also seems more consistent with the notion of disentangling output and capacity.

Idle capacity is then subject to two revisions, which proved to stabilize the model. For once, idle capacity is not allowed to exceed a certain share of presently installed capacity, so that not all capacity is dismantled in just one period. And secondly, when recent rates of output growth exceed some threshold $\hat{s}$, capacity reduction (or declaring capacity as "idle") will be halted. The reasoning could be that decision makers foresee a rise in utilization and prevent dismantling and subsequent build up of facilities.

In the end, the decision on whether to expand capacities or not depends on whether desired capacity exceeds the one installed taking into account the potentially existing idle reserves in capacity and present utilization compared to average utilization $\bar{\beta}_i(t)$. If additional capacity is needed, then finally the flexible accelerator comes into play, and distributes the expansion activities over several periods. Capacity is scrapped at no cost.

The model is best described by the following equations:

$$c_i^*(t+\tau) = \min\{1+\delta; \mu \cdot (1+s_{i,-1}) + (1-\mu) \cdot (1+s_{i,-2})\}^{\tau} \cdot c_i(t) \quad (1)$$

with $s_{i,-1} = \frac{x_i(t-1)-x_i(-2)}{x_i(t-2)}$, $s_{i,-2} = \frac{x_i(t-2)-x_i(t-3)}{x_i(t-3)}$

$$\alpha_i(t) = \max\left(0\,; c_i(t) - \frac{x_i(t)}{\hat{\beta}}\right) \quad (2)$$

$$d_i(t+\tau) = \min(\bar{\alpha}_{i,t-1}(t-1), \dots, \bar{\alpha}_{i,t-\psi}(t-1)) \quad (3)$$

with

$$\bar{\alpha}_{i,t-\psi}(t-1) = \alpha_i(t-1) \text{ for } \psi = 1 \quad (4)$$

$$\bar{\alpha}_{i,t-\psi}(t-1) = \alpha_i(t-\psi) - \sum_{\theta=t_1}^{t_2} d(\theta) \text{ for } \psi = 2, \dots, \Psi \quad (5)$$

where $t_1 = t + \tau - \psi + 1$, and $t_2 = t + \tau - 1$

$$d_i(t+\tau) = \begin{cases} 0, if \;\; s_{i,-1} < \hat{s} \\ \min(\bar{\alpha}_i(t-1), \dots, \bar{\alpha}_i(t-\Psi)), else \end{cases} \quad (6)$$

$$\tilde{d}_i(t+\tau) = \begin{cases} d_i(t+\tau), if \;\; d(t+\tau) < \tau \cdot \varphi \cdot c_i(t) \\ \tau \cdot \varphi \cdot c_i(t), else \end{cases} \quad (7)$$

with $\varphi < 1$ and $\tau \in N$

$$o_i(t+\tau) = \begin{cases} 0, if \frac{x_i(t-1)}{c_i(t-1)} < \bar{\beta}_i(t-1) \\ \max\left(0\,; c_i^*(t+\tau) - \left[c_i(t+\tau-1) - \tilde{d}_i(t+\tau)\right]\right), else \end{cases} \quad (8)$$

where $\bar{\beta}_i(t-1)$ is a moving average of capacity utilization in the past σ years in sector i, $\bar{\beta}_i(t-1) = \frac{1}{\sigma}\sum_{\theta=t-\sigma}^{t-1}\beta_i(\theta)$.

$$\bar{\mathbf{o}}(\mathbf{t}+\boldsymbol{\tau}) = \sum_{k=0}^{K} p_k \cdot \mathbf{o}(\mathbf{t}+\boldsymbol{\tau}-\mathbf{k}) \tag{9}$$

$$\mathbf{c}(\mathbf{t}+\boldsymbol{\tau}) = \mathbf{c}(\mathbf{t}) + \bar{\mathbf{o}}(\mathbf{t}+\boldsymbol{\tau}) - \tilde{\mathbf{d}}(\mathbf{t}+\boldsymbol{\tau}) \tag{10}$$

$$\mathbf{x}(\mathbf{t}) = [\mathbf{I}-\mathbf{A}(\mathbf{t})-\mathbf{R}(\mathbf{t})]^{-1}(\mathbf{B}(\mathbf{t}) \cdot \bar{\mathbf{o}}(\mathbf{t}+\boldsymbol{\tau}) + \mathbf{y}(\mathbf{t})) \tag{11}$$

Throughout the model, all constants in the matrices $\mathbf{A}(\mathbf{t})$, $\mathbf{R}(\mathbf{t})$, and $\mathbf{B}(\mathbf{t})$ should be equipped with actual values. However, this is only possible in ex-post simulations. The computations we carried out rely on unchanged input and capital coefficients for all periods after 2007.

3 Regional Input-Output Analysis

The regional context of analysis requires additional features concerning the input coefficients. As mentioned above, the German Statistical Office publishes national IO tables annually, from which technical and national input coefficients are computed. In contrast, no such table is published for Mecklenburg-Western Pomerania. Therefore, methods for the estimation of regional tables/input coefficients are necessary in order to assess the impact of final demand in the region on locally based enterprises and households.

There exist several modeling approaches to describe a regional economy by the means of an IO model. Generally one can distinguish between the interregional, the multi regional, and the *single region* model (Miller/Blair (2009) Ch. 3). The goods balance in a mutli regional model with 2 regions, r and s, could be written as follows:

$$\begin{pmatrix}\mathbf{x}^{\mathrm{r}}\\ \mathbf{x}^{\mathrm{s}}\end{pmatrix} = \left[\mathbf{I}_{2\mathrm{n}} - \begin{matrix}\hat{\mathbf{t}}^{\mathrm{rr}}\mathbf{A}^{\mathrm{r}} & \hat{\mathbf{t}}^{\mathrm{rs}}\mathbf{A}^{\mathrm{s}}\\ \hat{\mathbf{t}}^{\mathrm{sr}}\mathbf{A}^{\mathrm{r}} & \hat{\mathbf{t}}^{\mathrm{ss}}\mathbf{A}^{\mathrm{s}}\end{matrix}\right]^{-1}\begin{pmatrix}\mathbf{f}^{\mathrm{r}}\\ \mathbf{f}^{\mathrm{s}}\end{pmatrix} \tag{12}$$

Thereby, $\mathbf{A}^{\mathrm{r}}$ and $\mathbf{A}^{\mathrm{s}}$ represent the input structure of each region's economy, $\hat{\mathbf{t}}^{lk}$ the diagonal matrix of shares of purchases of region l in intermediate goods from region k. $\mathbf{f}^{\mathrm{r}}$ denotes the demand for goods in region r which is partly satisfied within the same region, and partly through imports from region s. In this model, the effects of regional demand within its borders and beyond can be estimated. Work on this type of models goes back to Isard (1951) and Moses (1955).

In a review of non-survey techniques for the estimation of trade coefficients, Schaffer, Chu (1969) find that all commonly used methods exhibit poor results (see also Round

1983). They suggest using any method only in conjunction with supplementary survey data. Also more recent tests show poor performance of classic location quotients, (Bonfiglio 2005; Bonfiglio, Chelli 2008). According to these authors the most promising approach is the Flegg et al. Location Quotient (FLQ), introduced by Flegg, Webber (1995) and refined in Flegg, Webber (1997) and Flegg, Webber (2000). The FLQ-method is based on the idea, that relative size of the selling and the purchasing industry on the one hand, and size of a region in conjunction with its propensity to import will determine the trade coefficients. Recent comparisons of FLQ-derived coefficients and multipliers with those of survey-based regional tables have shown much better performance of FLQ than of other conventional non-survey methods (see again Bonfiglio, Chelli (2008) as well as Tohmo (2004) and Flegg, Tohmo (2010)). FLQ writes as follows

$$t_{ij}^{rr} = flq_{ij} = \phi \cdot \left(\frac{x_i^r / x_i^n}{x_j^r / x_j^n}\right) \text{ where } \phi = \left[\log_2\left(1 + \frac{x^r}{x^n}\right)\right]^{\gamma} \tag{13}$$

where x denotes output of sectors i and j, in the region r and at national level, ϕ estimates the import propensity via size of the region and an adjustment parameter $0 < \gamma \leq 1$. The second term is the well known Cross Industry Location Quotient (CILQ). Since it will be equal to unity for $= j$, it is then replaced by $(x_i^r/x^r)/(x_i^n/x^n)$ resembling the simple location quotient (SLQ).[4] FLQ takes better account of cross-hauling than SLQ, since it is applied to each coefficient separately, thus allowing for different import shares among the customers of a sector and it takes into account the size of the region. On the contrary, it remains unclear, what the economic intuition of γ could be and how it should be estimated. Flegg, Tohmo (2010) give some hints on the choice of γ. However, since γ is applied to a region as a whole, it does not take into account the possible heterogeneity among different sectors' dependence on imports of other regions. In the end, however, the accuracy of estimations made by FLQ distinguishes it from other non-survey methods, and it shall therefore be applied in this work.

Finally, regional coefficient matrices enter in either static or dynamic IO analysis in the same fashion as the national survey based matrices, see Richardson (1985).

4 Data

4.1 Regional Economic Structure: Input and Capital Coefficients

Intraregional input coefficients where estimated in two steps. First, regional technical input coefficients $\mathbf{A}^{\mathrm{r}}$ were derived by aggregation of national technical input coeffi-

4 x^r and x^n denote total production in the region and in the country respectively.

cients using regional weights so as to consider the regional economic structure. Second, trade coefficients are applied to $\mathbf{A^r}$ to assess intraregional input coefficients $\mathbf{A^{rr}}$.

Therefore, national input-coefficients were aggregated from 71 to 12 sectors of production using regional weights. Output data on the regional level were not available, so employment data for each of the 71 sectors had to be used instead, taken from the (German) Federal Employment Agency (2011). However, only a slight change in input coefficients resulted. Total intermediate input share deviated most in sectors 2, 3, 4, and 5.[5] However, the deviations of the region coefficients from the national pendants were not stronger than 1.3%. Especially the coefficients on the main diagonal which have high absolute values show comparatively small deviations, so that the adjustment for regional structure has had little impact on overall outcomes of the model.

Next, trade coefficients were applied to discount purchases of intermediates from other regions. This was done via the FLQ formula represented by (13) in Section 3, again using employment data instead of output. The parameter for the region's size was set to $\gamma = 0.2$. Flegg, Tohmo (2010) found this value to minimize mean absolute percentage difference.[6] The FLQ-estimates of trade coefficients can be found in Table 2 in the Appendix.[7]

In the dynamic model, there are capital replacement coefficients $\mathbf{R(t)}$, next to input coefficients. However, IO accounts from the German Statistical Office do not provide the respective data. Stäglin, Edler, Schintke (1992) note that the issue of replacement coefficients is often not considered in theoretic discussions since it is assumed that input coefficients do account for replacement investments. However, IO tables of the German Statistical Office do not follow this principle. In order to compute results with the given IO model, replacement investments have to be ignored for the time being accepting that output calculated must be assumed to be underestimated.

The estimation of the capital coefficients $\mathbf{B(t)}$ is the second important step to generate data input for the dynamic IO model. Capital coefficients are also not provided by the German Statistical Office. They had to be calculated using capital stock estimates and output data. Capital stock data were taken from the "ifo Industry Growth Accounting

5 Sector 2: Mining and Natural Resources, Energy and Water supply; Sector 3: Refinery Production, Natural Oil and Gas, Chemicals; Sector 4: Production and Processing of Metals; Sector 5: Machines, Vehicles, and Data Processing.

6 *Flegg, Tohmo* (2010) is the only article known to this author where survey based coefficients are compared with FLQ-derived ones. Since the study was conducted in Finland, the authors of the present work abstain from using a specific region's optimal value for γ and use the overall best choice found in *Flegg, Tohmo* (2010) instead.

7 For the calculations FLQ trade coefficients were calculated for 2007 only and applied to all periods in the simulation to keep work effort concentrated on other, more sensitive issues.

Database 2008" [8] which provides data on capital stocks for 52 institutional sectors and 12 types of non-financial assets. For Documentation see Roehn, Eicher, Strobel (2007).

The sectors of the capital stock data base were aggregated so as to match the 12 production sectors from the input-output table of the German Statistical Office. In the same way, assets were assigned to corresponding goods categories in the IO scheme.[9]

The capital stock data in the "ifo Industry Growth Accounting Database" were only available until 2005, and in prices of 2000, Roehn, Eicher, Strobel (2007). Therefore, adjustment for price changes before assignment to input-output sectors using asset price indexes of the German Statistical Office (2011a) was necessary. For the application of the dynamic IO models capital coefficients were assumed to be constant after 2005.

One adjustment with respect to capital assets was made concerning the agricultural sector. This regards livestock, since it was not assessed in the "ifo Industry Growth Accounting Database". Data on average agricultural businesses' assets provided by the German Ministry of Food, Agriculture and Consumer Protection (2009) served to calculate the ratio of non-livestock to livestock assets.[10]

Finally, the output data from the 12-sector IO tables for 2000-2005 served to calculate capital coefficients for each sector and type of asset (German Statistical Office 2011c). The matrix with capital coefficients can be found in Table 4 the Appendix. Most rows purely consist of zeros, indicating that the respective sector does not supply any items used as productive capital stock by other sectors. The main suppliers of capital stock assets are sectors 5 (Machines, Vehicles, Data Processing and Electronic Devices) and 8 (Construction). Reading Table 4 column wise one can see the capital intensiveness of different production processes. Sectors 10, 2, and 1 rank highest (in that order), whereas all sectors of the processing branch, including construction works have very low capital coefficients. This may seem counter-intuitive at first sight. However, one has to bear in mind, that capital coefficients are based on output and capital. Output in turn is based on goods prices. Then, if a sector exhibits a low capital coefficient it does not necessarily mean that it employs little capital, but may also indicate high output prices or high productivity per Euro worth of capital used in production.

8 Available at http://faculty.washington.edu/te/growthaccounting/, visited on: 29.06.2011.

9 The assignment schemes can be requested from the authors: karl.zimmermann@tu-berlin.de.

10 The data provided by *German Ministry of Food, Agriculture and Consumer Protection* (2009) are average balance sheets of agricultural businesses in all of Germany. Similar data were not available for MWP. Furthermore, the data on assets of agricultural businesses refer to concepts financial accounting, rather than capital stock as in the ifo data base. However, again, for lack of better suited data, this approach has to suffice for the present work.

4.2 Past Tourism Demand

The third set of data was a time series of final demand vectors. Data for average expenditure of tourists staying overnight or making daytrips were taken from the surveys of Harrer, Scherr (2002); Harrer, Scherr (2010) and Maschke (2007). These provide data on visitors' average expenditures per day trip for the year 2006 and per overnight stay for the years 2000, 2004 and 2008. Expenditures on different types of goods and services were reassigned so as to fit IO conventions.[11]

In order to be applicable in an input-output model, data need to be measured at basic prices, net of trade and transport margins, and net taxes on goods and services. National data on ratios for supply at purchaser's prices and associated net taxes and margins were applied to convert tourism demand at purchaser's prices to basic prices. Data were taken from supply tables for the years 2000 to 2007 which are part of IO accounts (German Statistical Office 2010).[12] Finally, nominal demand was deflated. The authors used producer price indexes (PPIs)[13] (German Statistical Office 2010; German Statistical Office 2011b).

Table 1:
Number of overnight stays in Mecklenburg-Western Pomerania
- million of nights spent -

year, category of accomodation	< 9 beds	≥ 9 beds	camping grounds	day tourists
2000	4.20**	18.25*	5.30*	-
2004	-	21.35*	-	71.0$^{\alpha}$
2006	-	21.42*	-	70.0$^{\alpha\alpha}$
2008	4.50***	23.83*	3.67	

Sources: * Statistical Office Mecklenburg-Western Pomerania (2011); ** Harrer, Scherr (2002); *** Harrer, Scherr (2010); $^{\alpha}$ Maschke (2005); $^{\alpha\alpha}$ Maschke (2007).

Average expenditure per overnight stay and per day trip served to compute total expenditures by the two categories of tourists (*overnight stays* and *day trips*). The Statistical Office of Mecklenburg-Western Pomerania provides data only for overnight stays in businesses offering more than 8 beds and on camping grounds. Additionally, Harrer, Scherr (2002) and Harrer, Scherr (2010) estimated data on the number of stays in places with fewer than 9 beds for the years 2000 and 2008 (see Table 1). The number of day tourist stays in the region has been estimated in a survey by Maschke (2007), and amounts to a total of 70 million in 2006. Missing data points were estimated by inter-

11 Again, assignment schemes are can me made available upon request.

12 Deducting the share of net taxes in demand was done here in a rather rough manner, due to lack of resources. More precision could be gained by determining taxes applying to final consumers by type or category of goods consumed.

13 Specifically CPIs on services accommodation, transport and restaurants and cafés.

polation of per stay expenditure in real terms. Demand of day tourist was held constant in real terms.[14]

After adding day trip and overnight expenditure to a total tourism demand, adjustment back to current basic prices was conducted, so that they correspond to input coefficients.

4.3 Scenarios of Future Tourism Demand

The future development in tourism (demand) is subject to many influencing factors. The scenarios employed here have the function to integrate exogenous variables into the model[15] and assess their impact on production and employment over time assuming certain patterns of development of these exogenous factors. The aim of the presented work was especially to quantify the impact of climate change related variables on regional production, which manifests itself in three distinct scenarios on future tourism demand.

For the calculation of a future scenario on the number of overnight stays Mecklenburg-Western Pomerania, the present work relied on the work of Hirschfeld, Schröder, Wildgrube, Winkler (forthcoming). They presented three scenarios, based on past development of the number of overnight stays, and a number of other influencing factors. These are the state of **society** (demographics and travel preferences), **economy** (growth of disposable income and economic growth in general, competitive strength of other tourist destinations), **ecology** (natural scenery, water quality, biodiversity), and **political measures** (overall impact of government policy).

Relying on data for overnight stays in Mecklenburg-Western Pomerania for the years 1996-2011, a general growth trend was estimated by OLS which was then used to extrapolate. Next to that, the extrapolated trend was adjusted by a second growth rate, depending on the exogenous parameters mentioned above. The scenarios of future development of nights spent in the region writes as follows

$$w(t) = \eta \cdot w(-1) \cdot (\rho_{OLS})^{t+1} + (1-\eta) \cdot w(t-1) \cdot [1 + \iota_{scen}(t)] \quad (14)$$

where the first term denotes the extrapolated trend observed in the past and $\iota_{scen}(t)$ denotes a catchall parameter comprising all influencing factors depending on the respective scenario in period t. η denotes the weight of the observed trend in the past vis-à-vis the diverting impact of policy and climate scenarios. A critical point is clearly that estimators of the effect of exogenous influences on the number of overnight stays have been set based on qualitative explanations. Preset values of single factors' influences could be checked against empirical estimations.

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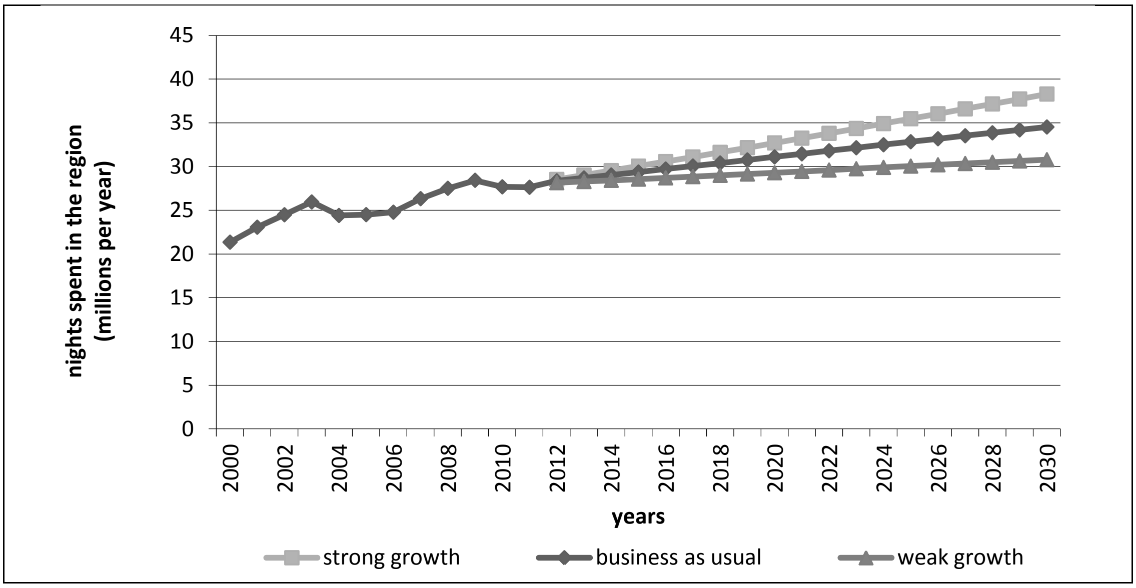
14 Years with available data are 2000 and 2008 for overnight tourists, and 2004 and 2006 for day tourists, see again *Harrer, Scherr* (2002); *Harrer, Scherr* (2010) and *Maschke* (2007). For day tourists deflated demand for 2000 − 2005 were set equal to the figures for 2004, and 2006-2008 equal to these of 2006.

15 These could be economic policies, demographic development and climate change impacts.

The three scenarios, which enter dynamic IO modeling in this work are: (1) *base line*, (2) *strong growth*, and (3) *weak growth*. Scenario (1) continues observed development in the number of overnight stays in Mecklenburg-Western Pomerania. It assumes continuous interest of tourists to come to the region, accompanied by continued investment in tourism related infrastructure as well as stable natural environment quality. Scenario (2) exhibits a strong increase in visitors' interest to come to the region. This was derived from climate change mitigation policies increasing the costs of long distant travel on the one hand as well continued good environmental quality. Furthermore it was assumed that tourism infrastructure investment is strongly promoted. In contrast to that, Scenario (3) draws a completely contrary outlook to scenario (2). Visitors' interest declines due to changing preferences, which do not match the region's profile. Additionally, natural environment quality deteriorates as a consequence of climate change and this further discourages tourists to spend their time in the region. Moreover, low government income in Mecklenburg-Western Pomerania does not allow for substantial improvements in tourism infrastructure.

Figure 1:
Scenarios of tourism development in the region
- million of nights spent per year -



Source: Hirschfeld, Schröder, Wildgrube, Winkler (forthcoming).

The scenarios are meant to be possible development schemes rather than forecasts. According to the assumptions, single influencing factors were changed and ι takes on different values, with $\iota_{(2)} > \iota_{(1)} > \iota_{(3)}$. The resulting developments of tourism can be seen in Figure 1. Based the number of guests in hotels/pensions larger than 8 beds on the one hand and the average expenditure pattern among all types of tourists on the other hand, time series of demand vectors were calculated for each of the three scenarios.[16] These served then, together with the demand in past years, as the data for exogenous demand in dynamic input-output modeling.

5 Implementation of the Model

The model comprises a list of parameters which have been set as follows. First, parameters concerning *desired capacity*: The maximum attainable growth of capacity has been set $\delta = 0.04$, since this resulted in capacity roughly growing at the pace of output. Larger or smaller values either lead to too little or too much capacity in the long run. The gestation lag of investments has been set to $\tau = 1$, meaning that investments were adding to capacity only one year after installment. Finally, the weight attached to recent growth as opposed to the growth rate the year before has been set to $\mu = 0.5$, so that there is an equal weighting of observed growth rates.

Second, there is a number of parameters connected to the determination of *overcapacity* and idle capacity: First, in determining overcapacity, a preset benchmark of normal capacity utilization was set to $\hat{\beta} = 0.8$. No differences were made among different sectors, and the value was chosen arbitrarily. It was beyond the scope of this work to go into empirical footage of capacity utilization or potential output studies.

Next, the backward looking horizon for a maximum of overcapacity was set to $\psi = 2$. The presence of much idle capacity may lead to actual reduction of capacity installed, but one of the new features of the non-linear dynamic IO model presented in this article is, that reduction has limited by an upper bound, which was set $\varphi = 0.25$.

Third capacity expansion: average capacity utilization $\bar{\beta}(t)$ enters as a correction measure in the determination of capacity expansion. It was set to rely on $\theta = 7$ most recent observations. This goes back to Edler, Ribakova (1993) who justify their choice with the supposed length of a business cycle. Last but not least, the flexible accelerator uses the weights $p_0 = 0.6$ and $p_1 = 0.4$, which also goes back to Edler, Ribakova (1993) who conducted tests on various combinations.

The model's results are quite sensitive to calibration. In order to start out with capacity covering also output triggered by investment (especially important to the construction sector), first, the model was run supposing that output in $t = 1$ only goes back to demand from final consumption. From that, capacity in $t = 1$ was derived supposing 80% capacity utilization. For $t = 2$ and $t = 3$., all sectors were "forced" to increase their capacity by the maximum attainable rate δ which triggers demand for investment goods in $t = 1,2,3$. In a second run, output was calculated again for $t = 1$ period, now includ-

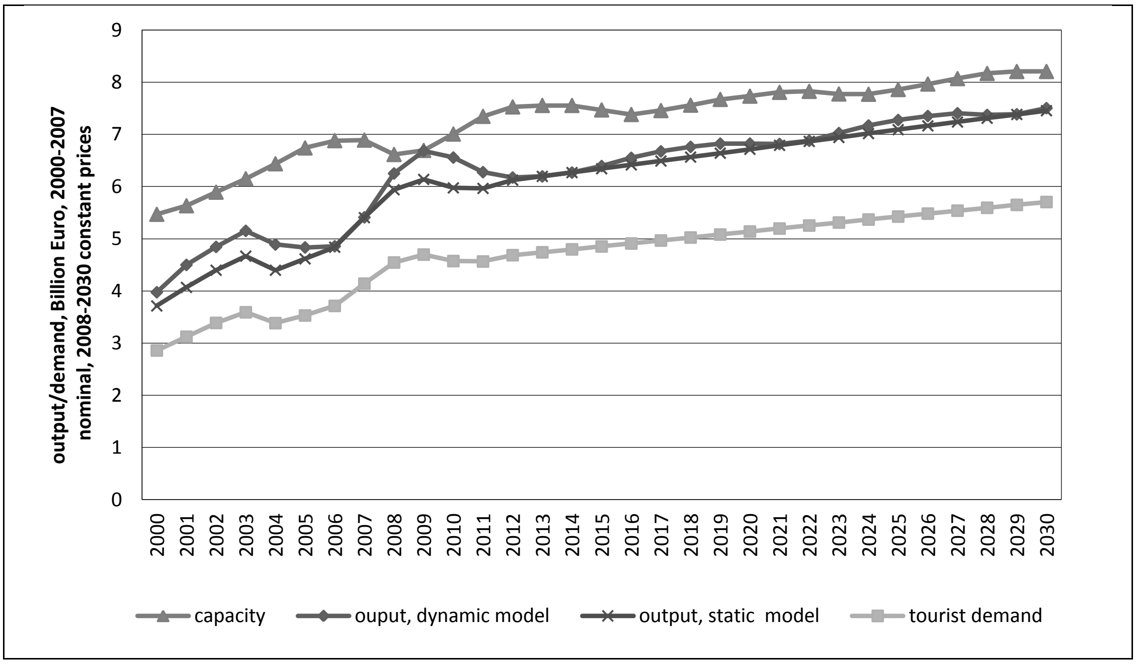
[16] This comes with the assumption that the amount of nights spent of different types of gests (large pensions/hotels, small pensions, camping grounds) showing different spending patterns stays the same in relative terms.

ing demand from investment. Obviously, initial capacity from this first run is too small, since it was based only on output stemming from production meeting final demand. Prior to the second run, the initial capacity was recalculated based on output in $t = 2$ of the first run, since only then, output fully incorporated investment – which is not fully fledged in $t = 1$ due to the flexible accelerator. These preset capacities represent the calibration, since they are the basis for coherent investment decisions. It is the question, whether this kind of calibration method − seeming rather pragmatic − could be replaced by assessing empirical data on potential output of single sectors.

5.1 General Results

Finally, some of to the computation results – the estimates of tourism related output, value added and wage bill – will be presented here. First, general results of the backward looking time span (2000-2011) will be shown to give an impression of the models estimation of the tourism related economic activities on the regional scale. Later, some light is shed on the impact of the scenarios and a particular change made in the model of Edler, Ribakova (1993).

Figure 2:
Model computations: aggregate tourism based demand, output and production capacity[a]
- billion Euro -



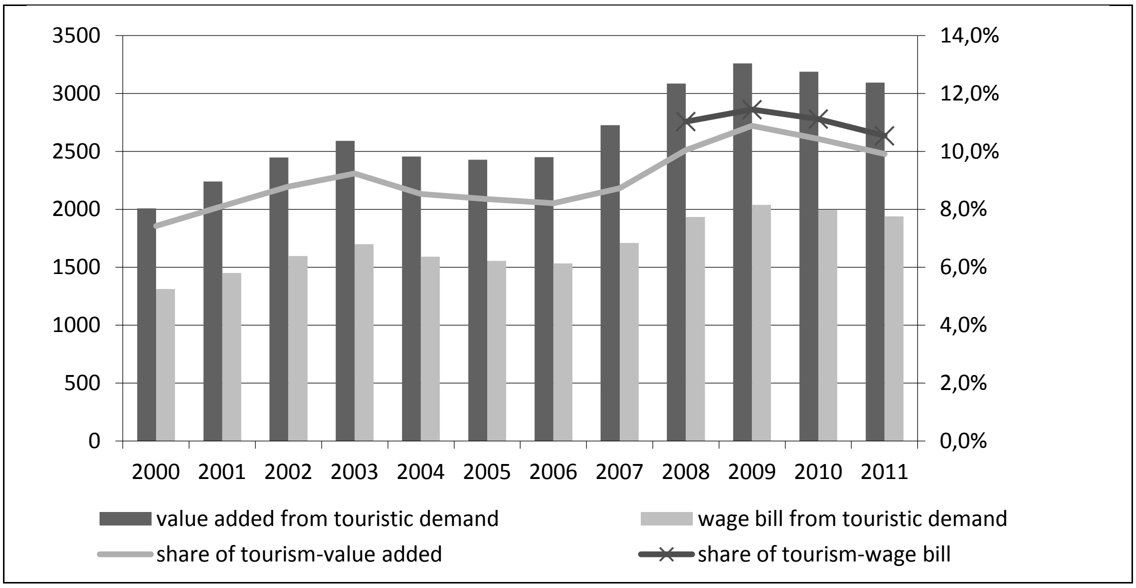
[a] Input-Output-Tables were only available up to 2007. Beginning 2008, it is assumed, that input-coefficients stay constant, meanwhile demand by tourists is measured in current prices in 2008 and in constant prices in succeding periods.

Source: Own Computations.

Figure 2 gives a general impression of the relation between aggregate demand and output (with and without induced investment). Demand rises from just below 2.9 in 2000 to 4.6 billion Euro in 2011 (current prices). Output is depicted by two graphs that move close to each other. The lower one results from the static IO computation, while the one above includes endogenous demand for investment in capacity. Output from the dynamic model rises from 3.9 (2000) to 6.2 (2011) billion Euro and in the static model from to and from 3.7 (2000) to 6.0 (2011) billion Euro. Since there is no IO table for the region, no comparison can be made to actual output in the region.

Using value added coefficients from the national IO table one can deduct estimates of the value added created regionally, see Figure 3. Value added from tourism demand rose from 2 billion Euro in 2000 to 3.2 billion Euro in 2010, and its share in total state value added rose from some 7.5% in 2000 to 10% in 2011. The wage bill amounted 1.3 billion Euro in 2000 and reached 1.9 billion Euro in 2011. Its share in the regional wage bill is just slightly above the share of value added.[17]

Figure 3:
Value added and wage bill induced by touristic demand
- total values (in mill. Euros) and shares on total regional figures (in %)



Source: Statistical Office Mecklenburg-Western Pomerania (2011a, 2012); own calculations.

In the present model, investment for capacity enlargement was introduced as an endogenously determined variable. However, it cannot be compared with data from national accounts. Introducing endogenous investment only increases the estimation of output going back to tourism by 1.97% compared with the static model (2010-2030, simulation period with constant prices), which clearly seems to underscore a realistic volume. This

17 No data prior to 2008 on the total wage bill where available for the region due to a change in the conventional framework of national accounting.

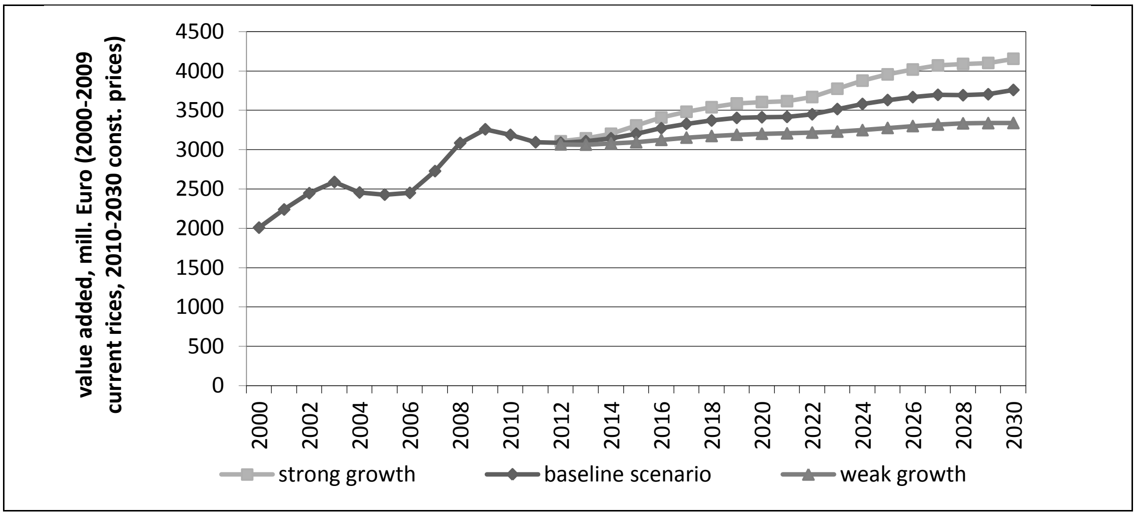
remains a point for future work on the model. Introducing replacement of depreciated capital stock is likely to flatten the course of output, since it generates more stable demand for sectors depending for now only on investment for capacity enlargement (such as construction or manufacturing).

At the present state, only a brief preview can be given with respect to the scenario outcomes. Deviations in aggregate output, value added and wage bill for scenario (2) and (3), strong and weak growth respectively are presented here. At a later stage, the authors intend to relate investment effort that leads to either of the scenarios to the outcomes of the present model in order to conduct a cost-benefit analysis of public investment in the context of climate change.

Recall that scenario (2) refers to high popularity of the region due to good environmental quality, mass tourism infrastructure and favourable climatic change. In contrast, scenario (3) draws quite different picture of not sufficient investment into infrastructure, bad environmental quality and non-favourable climate change in the region.

Figure 4 shows absolute deviations of value added depending on the underlying scenarios. The strong and the weak growth scenario deviate both by 800 mill. Euro of output (or 400 mill. of value added) by the end of the simulation period. In relative terms this is equivalent to a 10% of the base-line scenario volumes (where the relative deviation rises over time). Value added in scenario (2) rises strongly and reaches roughly 130% with respect to 2011. In contrast, scenario (3) yields a basically stagnant economic activity related to tourism.

Figure 4:
Regional aggregate value added induced by touristic demand (three scenarios)[a]
- million Euro -



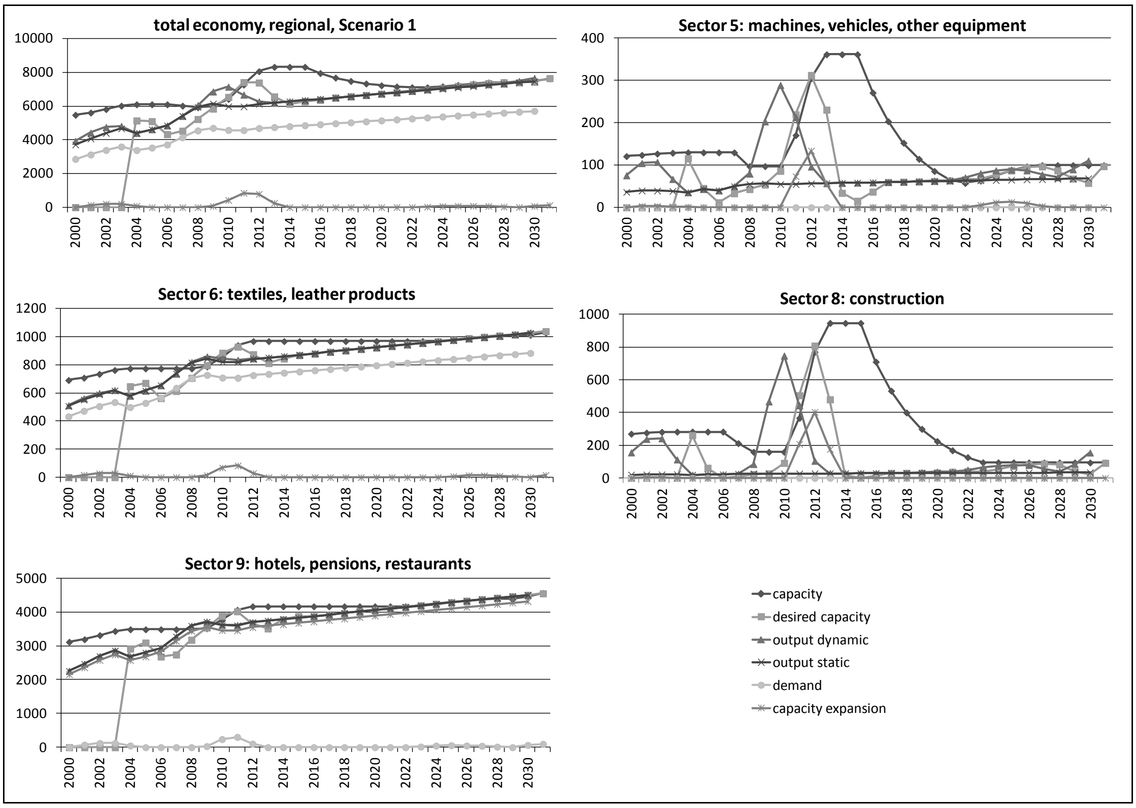
[a] Input-Output-Tables were only available up to 2007. Beginning 2008, it is assumed, that input-coefficients stay constant, meanwhile demand by tourists is measured in current prices in 2008 and in constant prices in succeding periods.

Source: Own calculations.

5.2 Improvements to the Non-linear Input-Output Model

As mentioned before, the non-linear dynamic IO model applied in this thesis mainly rests on the approach of Edler, Ribakova (1993). However, while reviewing the computational results, some changes were made regarding the decision functions which determine desired capacity c_i^* as well as idle capacity $d_i(t)$.

Figure 5:
Computation results using $x_i(t-1)$ instead of $c_i(t)$ for $c_i{}^*(t)$



Source: Own calculations.

The first change – regarding $c_i^*(t)$ – aimed at curbing two flaws. One was, that the investment-dependent sectors were subject to strong fluctuations in the computation results in the course of the present work. This applied especially to the construction sector. The other was the late reaction of capacity expansion. Both are due to the way Equation (1) is formulated. The strong oscillations are due to the fact that in Edler, Ribakova (1993) $c_i^*(t)$ depends on $x_i(t-1)$ and one of the growth rates.[18] This seems rather counter-intuitive, since that way, capacity is just a forecast on output, not taking into account a (benchmark) utilization rate, or in other words the notion of spare capacity (see Equation (1)). In the end, additional capacity is installed much too late and the regional economy as a whole runs into a state of over-utilization. Second, letting

[18] That is past output growth on the one hand and the maximum attainable output growth on the other.

$c_i^*(t+\tau)$ depend on $x_i(t-1)$ caused instability in the computations of the present study. Once an increase in production occurred, desired capacity increases manifold only two periods later. This mechanism is even increased by the notion of revised capacity $\bar{c}_i^*(t)$, even if one replaces $x_i(t-1)$ by $c_i^*(t)$, since it reintroduces recent output again by dividing it by maximum recent capacity utilization β^{max}. Therefore, $x_i(t-1)$ was replaced by $c_i(t)$ in Equation (1) and the notion of revised capacity $\bar{c}_i^*(t)$ as presented in Edler, Ribakova (1993) was abandoned. Output fluctuations continue to be present especially in the sectors lacking exogenous final demand. These are, however, much less profound. To show evidence to the argument, see the performance of the variables in Figure 5, where in the model presented here, in Equation (1), $c_i(t)$ was replaced by $x_i(t-1)$.[19] The strong oscillations are also due to the unbalanced demand of tourists, mainly consisting of services (accommodations and gastronomy). This leaves some sectors without any exogenous demand, thus depending purely providing input to other sectors. Especially the manufacturing and the construction sector showed very volatile behavior, since the supply investment goods but exhibit no exogenous demand.

Furthermore, revising the computations, a maximum share of scrapping installed capacity was introduced, Equation (7) as well as reaction to strong past output growth rates, Equation (6). The latter expansion of the model introduces indirectly some kind of expectation concerning future periods. Previously unused capacity will be used again when a strong upswing could be observed recently. Equation (7) in turn was introduced on the likeliness of constraints in the regional economy's capacity to scrap capital stock and secondly that the authors consider it unrealistic, that a whole sector of production reduces its capacity in 1 or 2 periods.[20]

6 Conclusion

In the present work, a non-linear dynamic IO model has been presented. It was used to quantify output, value added and wage bill going back to demand from tourists coming to the German State of Mecklenburg-Western Pomerania. Tourism was estimated to have grown from a share in regional value added of 7.5% in 2000 to 10% in 2011. Since replacement investment was accounted for in the model, this is rather underestimating the true impact of touristic demand.

In order to simulate future development of tourism related activities in the region, three scenarios on the number of nights spent were used (*business as usual*, *strong growth* and *weak growth*). In the *strong growth* scenario, value added from tourism is calculated to rise by about 30% by 2030 (in real terms) compared to 2011. Whereas in the

19 Also the exponent of the growth rate was adjusted to $\tau+1$.

20 The maximum share of capacity that a sector is allowed to scrap is 25%, which means that all production facilities of a sector cannot be dismantled faster than in four years.

weak growth scenario value added will not even reach its 2009 peak again throughout the simulation period until 2030. Since the scenarios are describing tourists reaction on a variety of influencing factors – among others demographic change, overall economic growth, global warming, infrastructure policy and climate change adaptation measures – they will later be used in a cost-benefit analysis of alternative adaptation strategies. Up to this point, a mere estimation of the tourism based economic impact has been undertaken.

During the work on the model of Edler, Ribakova (1993), the authors of the present study made some changes to the original model in order to stabilize its outputs. Further works needs to be done with respect to the modeling of capital stock maintenance and depreciation. Next steps will also be to further regionalize the model towards the counties directly along the shore and to extend it to the respective counties in Schleswig-Holstein. And finally, other sectors of the regional economy will be analyzed in similar detail.

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Appendix

Table 2:
Sectors' description

1	Products of Agriculture, Forestry and Fishery
2	Products of Mining, Extraction of Natural Resources, Energy and Water Supply
3	Products of Refinery of Natural Oil and Gas, Chemical Products
4	Production and Processing of Metals
5	Machines, Vehicles, Dataprocessing and Electronic Devices
6	Textiles, Leather Products, Wood and Paper-related Products, Recycling
7	Foodstuffs, Beverages, Tabacco Products
8	Construction Work
9	Services related to Retail, Wholesale Trade, Transport, Hotels and Restaurants, Post and Telecommunication
10	Financial Intermediation, Insurance and Pension Funds, Auxiliary Financial Services, Renting and Real Estate Services, Computer-related and other Business Services
11	Health and Veterinary Services, Education, Schooling, Social Work
12	Public Administration, Defense, Social Security Services

Source: Own classification.

Table 3:
FLQs for the year 2007

Sectors	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	1.000	1.000	1.000	1.000	1.000	0.787	1.000	1.000	1.000	1.000	1.000
2	0.046	0.146	0.284	0.097	0.110	0.165	0.074	0.136	0.295	0.159	0.099	0.114
3	0.078	0.832	0.250	0.167	0.188	0.282	0.127	0.232	0.505	0.273	0.170	0.194
4	0.229	1.000	1.000	0.731	0.549	0.823	0.370	0.678	1.000	0.796	0.496	0.568
5	0.203	1.000	1.000	0.431	0.648	0.729	0.328	0.601	1.000	0.705	0.439	0.503
6	0.135	1.000	0.840	0.288	0.324	0.432	0.219	0.401	0.871	0.471	0.293	0.336
7	0.300	1.000	1.000	0.639	0.722	1.000	0.961	0.892	1.000	1.000	0.652	0.747
8	0.164	1.000	1.000	0.349	0.394	0.590	0.265	0.524	1.000	0.571	0.355	0.407
9	0.075	0.802	0.469	0.161	0.181	0.272	0.122	0.224	0.241	0.263	0.164	0.187
10	0.140	1.000	0.868	0.297	0.335	0.503	0.226	0.414	0.900	0.447	0.303	0.347
11	0.224	1.000	1.000	0.477	0.539	0.808	0.363	0.666	1.000	0.781	0.717	0.557
12	0.196	1.000	1.000	0.417	0.470	0.705	0.317	0.581	1.000	0.682	0.424	0.626

Sources: Own calculations, regionalization: Genisis database of the German statistical office, http://www.statistikportal.de/Statistik-Portal/GenesisUebersicht.asp (11.09.2012).

Table 4:
Capital coefficients for the year 2005

Sectors	1	2	3	4	5	6	7	8	9	10	11	12
1	0.187											
2												
3												
4	0.068	0.027	0.014	0.015	0.007	0.025	0.015	0.013	0.018	0.004	0.023	0.011
5	0.731	0.821	0.268	0.185	0.195	0.368	0.214	0.094	0.245	0.244	0.187	0.172
6	0.002	0.015	0.008	0.006	0.007	0.023	0.008	0.009	0.026	0.007	0.056	0.040
7												
8	2.080	2.184	0.193	0.150	0.143	0.320	0.250	0.149	0.653	4.402	2.275	2.649
9												
10	0.002	0.007	0.002	0.002	0.003	0.006	0.002	0.003	0.010	0.018	0.019	0.015
11												
12												

Sources: Own calculations, German Statistical Office (2011c), Roehn, Eicher, Strobel (2007).