Transportation and Quality of Life

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August 26, 2019

Abstract

Keywords: quality of life, transportation.
JEL Classification: .

1 Introduction

This paper studies the importance of transportation for the quality of life in Denmark. The average Dane spends about 55 minutes on transport per day (DTU [2013]) and the average household's expenditure devoted to transport is about 20 % of the total household budget (Berri et al. [2014]).[1] It is therefore important to recognize the importance of transportation for the quality of life.

Transportation is derived demand as individuals often consume the service not because they benefit from consumption directly, but because they partake in other consumption or activities elsewhere (see e.g. Small and Verhoef [2007]). Transportation allows households to buy consumption goods

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[1] About 90 % of the average household's expenditure devoted to transport went to private transport. Private transport expenditures include purchases of cars and two-wheelers; insurance costs for cars and two-wheelers; purchases of fuels, lubricants, tyres and accessories; maintenance and repair costs; parking costs; lock-up garage or parking lot rental costs; car licence and annual registration taxes, and vehicle use-related fines. For more details see Berri et al. [2014].

and activities, get to work and enjoy leisure.[2] Households therefore face in general trade-off between, on one hand productivity and consumption advantages (high-paying jobs and high quality local urban amenities), and on the other hand higher costs of living and dis-amenities (high housing costs, congestions and pollution), when they decide where to live.

Transportation infrastructure facilitates interaction within cities. It relieves pressure on urban land by enabling workers to live at some distance from their jobs at reasonable commutes. Transport infrastructure thus affect the attractiveness of urban areas.

We construct a transport adjusted Quality of Life Index (QLI) for the 98 urban areas - municipalities - covering Denmark. Using this index we investigate the importance of adjusting for the inter area commute patterns in terms of the quality of life of a typical household. We also investigate the relationship between transport infrastructure investments and the QLI.

2 Theory

We follow Albouy and Lue [2015] and extend the Rosen [1979] model by including commuting cost. Households are assumed to be homogeneous, perfectly mobile and fully informed about the municipality characteristics. They consume housing y at municipality specific price p_j, a traded good x with the price normalized to one, as well as leasure time l and commuting time f. Each municipality grants access to the amenities z aggregated into a single index $Q = Q(z)$. The preferences of households are represented by the quasi-concave utility function $U(x, y, l, f, Q)$ that is increasing in x, y, l, Q and decreasing in f.

Households choose a municipality of residence j and a municipality where they work k. They also choose consumption levels of x, y and how many hours to work h. The resulting household budget constraint is

$$x + p_j y \leq w_k h - \tau(w_k h) - cf_{jk}, \tag{1}$$

where $\tau(w_k h)$ is tax of wage income and cf_{jk} are the monetary cost of commuting. Households are also constrained with respect to the time available which is standardized to 1 and used on commuting f, working h and leisure

[2] Travel may also have direct consumption value (Couture et al. [2018]).

l. In spatial equilibrium the expenditure function gives rise to the equation

$$E(p_j, w_k, f_{jk}, Q_j, u) := \min_{x,y,h,l}\{x + p_j y - w_k h + \tau(w_k h) + c f_{jk} \quad (2)$$

$$: l + f_{jk} + h \leq 1, U(x, y, l, f, Q) \geq u\} = 0,$$

where u is the equilibrium level of utility. Implicit differentiation with respect to j gives the following two equations

$$\frac{\partial E}{\partial p_j} dp_j + \frac{\partial E}{\partial f_{jk}} df_j + \frac{\partial E}{\partial Q_j} dQ_j = 0 \quad (3)$$

$$\frac{\partial E}{\partial w_j} dw_j + \frac{\partial E}{\partial f_{jk}} df_k = 0. \quad (4)$$

These equations are then combined to get

$$-\frac{\partial E}{\partial Q} dQ_j = \frac{\partial E}{\partial p} dp_j + \frac{\partial E}{\partial f} df_{jk} + \frac{\partial E}{\partial w} dw_k, \quad (5)$$

having defined $df_{jk} := df_k + df_j$. Applying the envelope theorem in order to get derivatives of the expenditure function and evaluating the derivatives at the national average we rewrite to get

$$-\frac{\partial E}{\partial Q} dQ_j = \bar{y}\bar{p}_j + [c + (1 - \tau')\bar{w} - \alpha] df_{jk} - (1 - \tau')\bar{h} dw_k, \quad (6)$$

where $\alpha := (\partial U/\partial f - \partial U/\partial h)/(\partial U/\partial x)$. In order to operationalize this equation it is reformulated in terms of differentials $\hat{z} := (z - \bar{z})/\bar{z}$ and divided with $\bar{m}$ the national average of total consumption

$$-\frac{\partial E}{\partial Q}\frac{dQ_j}{\bar{m}} = s_y \hat{p}_j + \left[s_c + s_w \frac{\bar{f}}{\bar{h}}\right] \hat{f}_{jk} - s_w \hat{w}_k, \quad (7)$$

where $s_y := \bar{y}\bar{p}/\bar{m}$ is the expenditure consumption share for housing, $s_c := c\bar{f}/\bar{m}$ is share of consumption spent on commuting and $s_w := (1 - \tau')\bar{h}\bar{w}/\bar{m}$ is the disposable wage income as a fraction of total consumption expenditure. Furthermore we assume that the marginal commuting time is valued as work time such that $\alpha = 0$. Finally we multiply with $\pi(k|j)$ the share of residents in municipality j working in municipality k and sum over workplaces in order to get

$$-\frac{\partial E}{\partial Q}\frac{dQ_j}{\bar{m}} = s_y \hat{p}_j + \left[s_c + s_w \frac{\bar{f}}{\bar{h}}\right] \hat{f}_j - s_w \hat{w}_j, \quad (8)$$

with $\hat{f}_j := \sum_k \hat{f}_{jk}\pi(k|j)$ and $\hat{w}_j := \sum_k \hat{w}_k\pi(k|j)$. The left hand side is the marginal willingness-to-pay for local amenities as a fraction of total consumption expenditure.

3 Data

To evaluate the right hand side of Equation (8) we combine several sources of data. To construct the wage index by municipality $\hat{w}_j$ and estimate conditional probabilities $\pi(k|j)$ we use a micro data set for the full population of workers in the year 2010. The dataset is derived from annual register data from Statistics Denmark for the year 2010 and includes information on workers residence and workplace (both at the municipal level), hourly wages, and a range of explanatory variables for each worker: educational level, age, gender, full-time versus part-time, and the sector of employment. The price index $\hat{p}_j$ for housing is constructed using a dataset of all the realized real estate transactions for the year 2010. This data set includes transaction price and the structural attributes, such as age of building, size (sqm) and number of rooms. The commuting time index $\hat{f}_{jk}$ is based on a data set of travel times, mode choice and trip frequencies for the year 2010 from the Danish National Transportation model. In addition to the micro data sets and the transport model data we also use the aggregate data tables FU09 and FU02 from Denmarks Statitics. These tables provide information on the aggregate consumption and income and allow us to calculate s_y, s_c and s_w.

4 Empirical Results

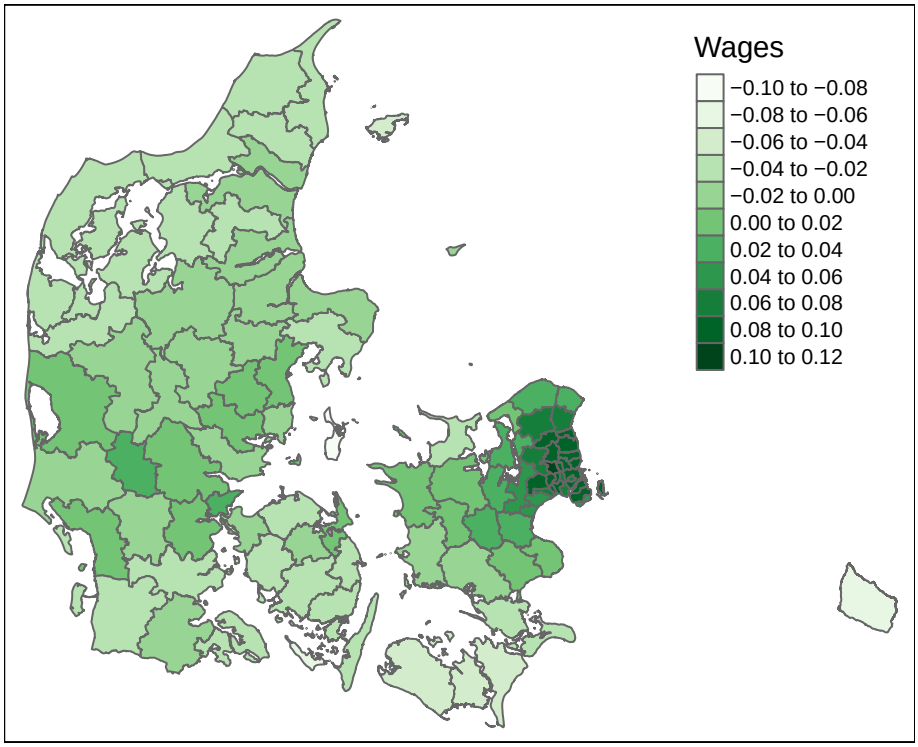
In order to construct the wage index $\hat{w}_k$ we use hourly wages from the 2010 population of full time workers. We define full time workers as individuals with more than 30 hours of work per week on average during the year. The log of wages are then regressed on municipality of work indicators μ_k as well as controls for worker attributes $\mathbf{x}_i$. The regression equation is

$$\log w_i = \mathbf{x}_i^\top \beta + \mu_{k(i)} + \epsilon_i \tag{9}$$

where $k(i)$ is the municipality of work of individual i. Importantly the regression are run by municipality of work not by residence and then the estimates $\hat{\mu}_k$ is used to calculate the wage differential $\hat{w}_j = \sum_k \hat{\mu}_k\pi(k|l)$.

We find that wage differentials $\hat{w}_j$ are substantially higher in the Greater Copenhagen Area and other large cities in Denmark (Aarhus, Odense and Aalborg) as illustrated in Figure (1). We also find that heterogeneity of workers is important when estimating wage differentials $\hat{w}_j$. For example, before correction for worker heterogeneity, the percentage wage gap between the municipality with the lowest and the municipality with the highest wages is about 50 %. This gap reduces significantly when correcting for the observed heterogeneity.

Figure 1: Wage index by place of work

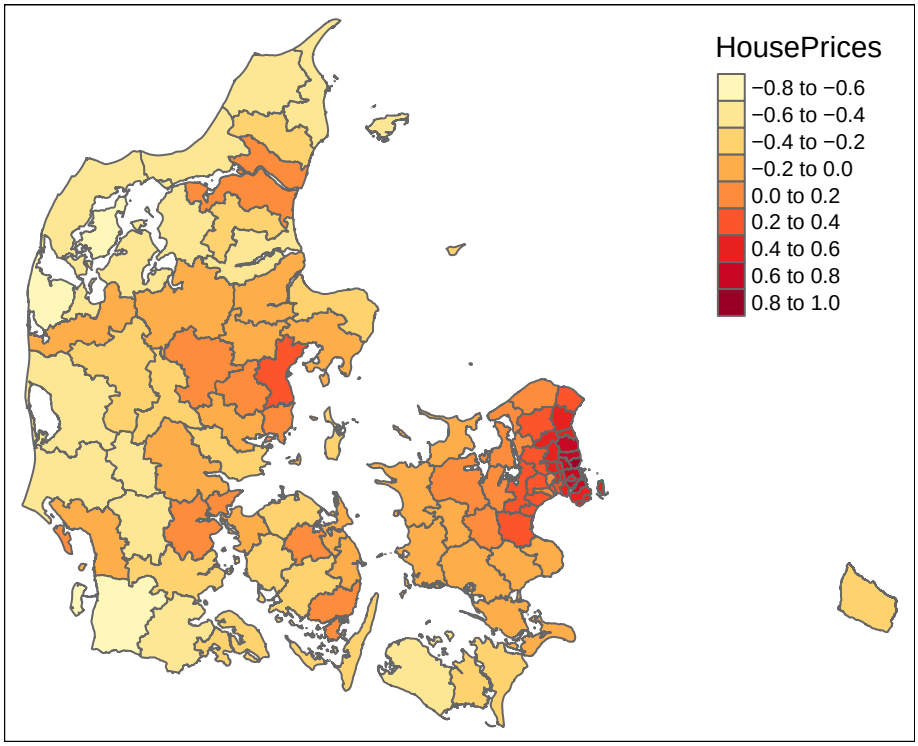


The housing price index $\hat{p}_j$ is constructed in a similar fashion using all realized real estate transactions from the year 2010. Specifically the log of the sales price is regressed on housing characteristics $\mathbf{x}_s$ and a municipality indicator $\mu_{j(s)}$ with $j(s)$ being the municipality where the house s is located. The regression equation is therefore given as

$$\log p_s = \mathbf{x}_s^\top \beta + \mu_{j(s)} + \epsilon_s, \tag{10}$$

and the estimates $\hat{\mu}_j$ are used as the housing index. Not surprisingly we that find that the urban areas of

Figure 2: Housing price index



We find a strong positive correlation between $\hat{w}_j$ and $\hat{p}_j$ (correlation coefficient is 0.76). Finally, our estimation results suggest that the marginal willingness-to-pay for local quality of life $\hat{Q}_j$ is higher in cities as well, see figure (4). More interestingly, we find a negative relationship between distance to the nearest highway ramp and $\hat{Q}_j$. Our empirical results suggest that 1 % reduction in the distance to the nearest highway ramp is related to 0.2 % increase in the marginal willingness-to-pay for local quality of life $\hat{Q}_j$.

Figure 3: Marginal willingness-to-pay for local amenities $\hat{Q}_j$

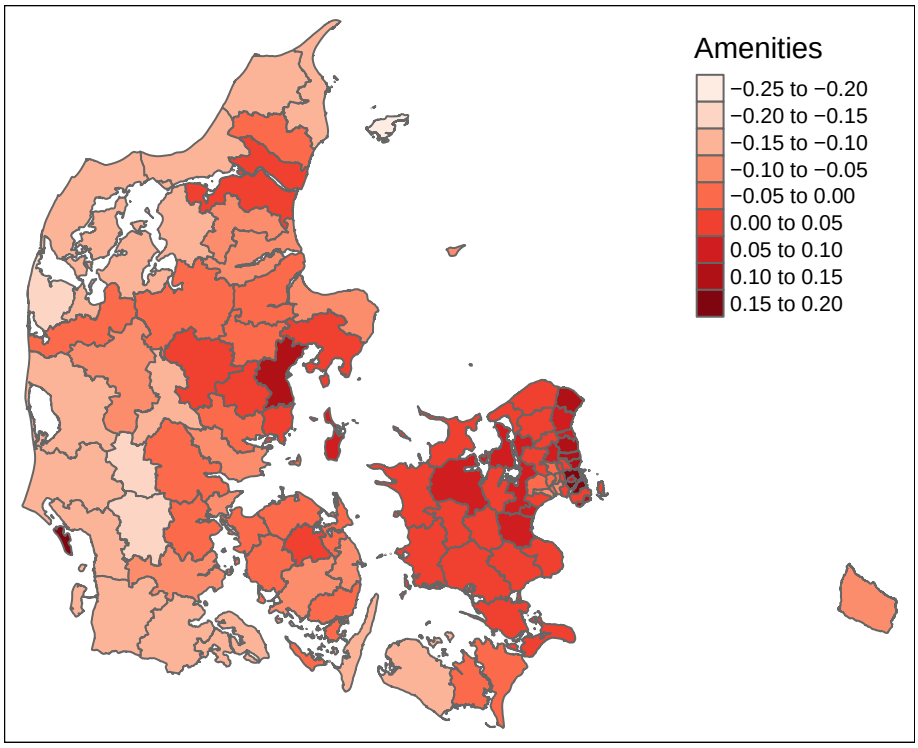
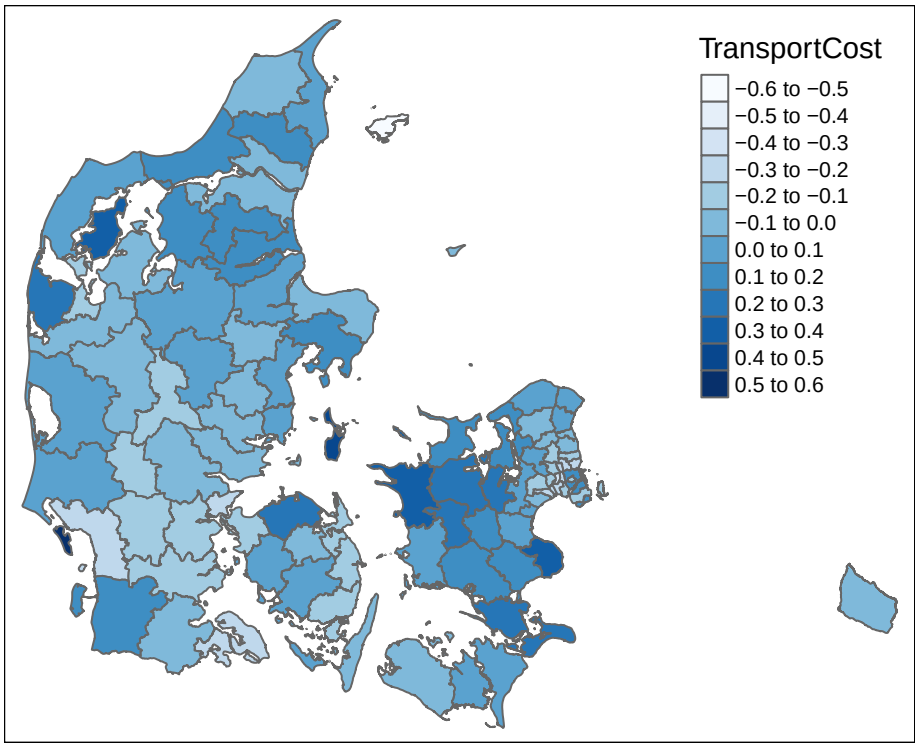


Figure 4: Marginal willingness-to-pay for local quality of life $\hat{Q}_j$



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