Location of the labour force in an interregional general equilibrium model – an applied case

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January 2003

Paper presented to the 43rd Congress of the European Regional Science Association, Juväskylä, Finland, August 27 to August 30, 2003.

Abstract

The consequence of low level of infrastructure between the metropolitan area of Copenhagen and the Western and Southern areas – the counties of Vestsjælland and Storstrøm – is analysed. The metropolitan area of Copenhagen has experienced economic growth in the past decade and the demand for labour is rising. The analysis considers economic effects of the level of infrastructure, via the interaction with the labour market. An interregional general equilibrium model of the two regions has been constructed and a case with better infrastructure is analysed. The heterogeneous labour force differs with respect to taste of leisure and taste of residential location. In the model better infrastructure results in more willingness to search for a job in both regions, but infrastructure investment has to be financed, commuting generates emissions, and regional price effects influence the equilibrium. Costs and benefits are included in the modelling.

JEL classification: J6, R13

Key words: Labour mobility, commuting behaviour, job search.

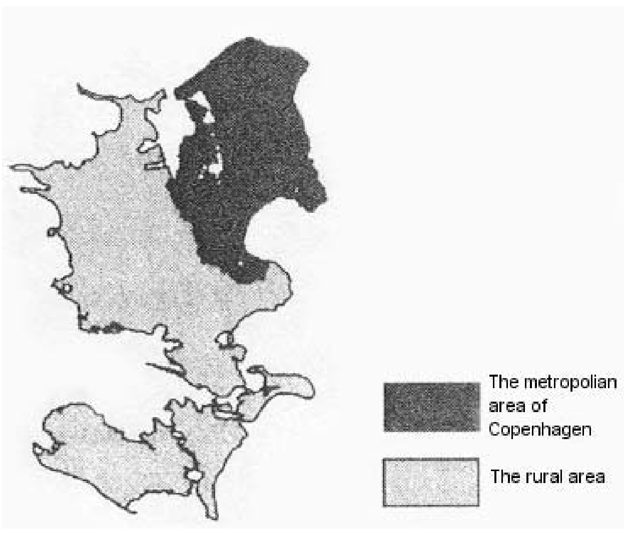
1. Introduction

This paper focuses on the economic consequences of increasing infrastructure investments in a regional perspective. The effects are defined to only deal with the regional labour markets. These are important ingredients when infrastructure projects are planned. Also environmental emissions are included in this analysis. The scope of this paper is to compare and rank the effects and to demonstrate that economic models have a story to tell when infrastructure is considered. Whether or not the economic effects are crucial naturally depends on the specific case. The case examined in this paper is a hypothetic one in a topical setting.

Zealand is about to melt together in one commuting area as Andersen (2000) demonstrates, but it does not imply that Zealand is integrated one hundred percent. The counties of Storstrøm and Vestsjælland have both regretted the poor connections to the metropolitan area, and the two counties are trying to convince the Danish State that transport investments are needed. Both public and private conditions are proposed to be improved[1].

This paper analyses a hypothetical transport investment between two Danish regions, namely the metropolitan area of Copenhagen and the two counties of Storstrøm and Vestsjælland defined as the rural area and presented in figure 1.1.

Figure 1.1. The two regions of Zealand, Møn, Lolland, and Falster



[1] Storstrøms Amt (2002).

The definition of the two regions is inspired by Tonboe (2002), from which the main part of the figure is reproduced.

A regional general equilibrium model is established to evaluate long-run effects. The model is partial in the sense that only commuting is analysed. Commuting causes about one quarter of an individual's daily transport effort measured in kilometres in Denmark in 1999. The remaining daily transport effort is due to for instance transport of commodities, leisure travel, and shopping. Consequently, this paper is not a total cost-benefit analysis of a transport investment between the two regions. On the other hand, the effects on commuting are more intensively analysed compared to a traditional cost-benefit analysis.

The model used in this paper is almost identical with the one described in Larsen (2002 II) which includes a detailed description of all equations in the proto model. This paper will not examine every equation in detail. On the other hand, a brief introduction together with evaluation of significant effects is presented so this paper is meant to be read independent of Larsen (2002 II).

The paper is organised as follows. Section 2 presents an overview of the model, and in section 3 the base year is calibrated. Section 4 outlines the experiment. Section 5 presents the results of the transport investments and the conclusion is in section 6.

2. Model introduction

The model is dynamically formulated, but is only solved in steady state. Comparative static between the steady state before the experiment and after the experiment is examined. It is a long-run model with one hundred eleven model equations and twenty four equations which afterwards calculate the utility measures.

The labour market is basically the one described in Pissarides (2000) where unemployment is present because it takes time to find a job. The main difference between the labour market presented in Pissarides (2000) and the labour market in this model is that here workers are heterogeneous with respect to taste for leisure and residential location. Only the labour force of the two regions is included in the model and the only factor input in the production is labour.

The workers in the labour force are able to move residence and choose where to search for a job. Only unemployed workers search for a job and they select one of the following strategies: The residential search strategy (RSS), the commuting search strategy (CSS), or the moving search strategy (MSS). In general, RSS is chosen if the worker has high preferences for living in a specific region and has high preferences for leisure. The disadvantage of RSS compared to the two other strategies is that the worker has less probability to get a job. The CSS is chosen if the worker has sufficiently high preferences for the residential location, but sufficiently low preferences for leisure. MSS is typically chosen if the worker has little or no utility of the residential location. The main differences between RSS and MSS are that a commuter has to consider commuting and time costs where a mover has to be willing to live in both regions. When the workers choose their strategy they are considering regional wages, regional housing prices, commuting costs, regional taxes, the allowable tax deduction for commuting costs, distance, leisure, the regional probability of getting a job and the level of the unemployment benefits. It is the heterogeneity of leisure and residential location which results in different choice of search strategy.

In both regions there are a commodity-producing sector which produces a regionally commodity which is different from the one produced in the other region. The commodity-producing sector is the dominating sector in both regions. There is a local wage negation between the employer in the commodity-producing sector and the employees. A Nash bargaining process leads to a wage agreement which other sectors take for granted.

Two regional sectors produce local housing using local labour. In the long run the supply curve for local housing is horizontal which would not have been the case if land was included in the model as a factor input. Hereby all short run problems on the local housing market are ignored. Housing in the model plays an endogenous role of the search strategy of the workers. A region with higher housing costs will be less attractive than a region with lower housing costs. The price of housing is connected with the development in the local wage and not directly with the number of inhabitants in the region. In the short run it would be natural to assume that increasing population would result in increasing housing costs. The same effect is in the model, but the theory differs. With an increasing population the local labour needed for producing local housing is increasing which implies that less mobile goods are produced in that region. This has a tendency to increase the price of the regional mobile good and hereby also the regional wage and the regional housing price. By this, increasing population will result in increasing housing costs other things being equal.

Labour is also needed to make commuting possible. There are four commuting flows in the model: Inside the metropolitan area, from the metropolitan area to the rural area, inside the rural area, and from the rural area to the metropolitan area. Each commuting flow is represented by a transport sector. In this sector it is assumed that the labour of the transport sector locates in the place of residence of the commuters.

The regional public sector in the model does not produce any goods. The regional public sector decides the size of the regional taxes and the regional tax deductions. Furthermore, a national level of the unemployment benefit and the tax deductions for commuting are agreed upon. The public sector balances because the difference between the total profit and the total loss is transferred via lump-sum transfers at a national level to every member of the labour force.

The analysis of a general equilibrium model and transport is found Krugman (1979), who introduces increasing return to scale in production as it is assumed that the consumers love variation of commodities. Isard et al. (1998) present transport in a general equilibrium model with the starting point in input-output tradition. Bröcker (1998) includes multi-dimensional model in which transport is modelled like Samuelson's iceberg model. In Bröcker transport is not treated as a separate sector, but a part of the commodities simply vanish when transported. In Isard et al. (1998) the iceberg approach is criticised of being a too simple assumption when dealing with transport. Tavasszy et al. (2002) describe why and when the iceberg approach is a misspecification of the transport model.

The search theory equilibrium approach to transport was the topic of Munksgaard and Pilegaard (2000) who developed a model which included transport mode in a three region setting. Pilegaard (2003) develops a nested multiregional setting including leisure travel. Larsen (2002 I) divided Denmark into three regions: Centre, neighbouring area, and rural regions and analysed the consequences of a reduction in the tax deduction for commuting, but no migration was possible. Search equilibrium theory studies with location and commuting are also analysed in van Ommeren, Rietveld and Nijkamp (2000), but unlike Larsen (2002 II) and this paper, workers are not heterogeneous with respect to leisure time and preferences of regions. Van Ommeren and Rietved (2002) develop a multiregional setting.

3. Calibration of the base year

When making comparative static analysis with a static general equilibrium model one has to calibrate a base year that satisfies the features of the model. The year 1996 is chosen as base year duo to practical data reasons and because it is not a year at the bottom or the top of a business cycle. The key values of the regional labour market have been exogenous in the calibration process and they are presented in table 3.1.

Table 3.1. Labour market data 1996

	Place of residence metropolitan area	Place of residence rural area	Total
Employed workers			
Place of production, metropolitan area	897,292	39,019	936,311
Place of production, rural area	11,409	224,895	236,304
Total	908,701	263,914	1,172,615
Unemployed workers	86,990	27,093	114,083
Labour force	995,691	291,007	1,286,698
Unemployment percent	8.7 %	9.3 %	8.9 %

Source: AKF's regional accounting system.

The figures in table 3.2 are calibrated to be as close to the national levels as possible because no regional data have been available.

Table 3.2 Labour market – calibrated data

	Metropolitan area	Rural area
Unemployed workers – RSS		
Average duration of an unemployment spell	6.4 months	8.5 months
Unemployment percent 1)	9.6 %	12.4 %
Unemployed workers – CSS and MSS		
Average duration of an unemployment spell	3.6 months	3.6 months
Unemployment percent 1)	5.7 %	5.7 %
Duration of an employment spell	60 months	60 months
Average waiting time of job openings	6 months	6 months
Labour market tightness	0.940	0.705
Number of job openings	86,773	21,341
Number of job searchers	92,318	30,281

Source: AKF's regional accounting system.
1) Exclusive of workers in the non-mobile sector.

Note, that the unemployment spell between CSS and MSS are the same by definition. There are two possible reasons within this theoretical setup why unemployment in the metropolitan area of Copenhagen is higher than in the rural area. The willingness to search for a job could be lower in the rural area and the unemployment spell could be longer in the rural area. The number of commuters from the rural area is 15% of the labour force whereas only 1% of the labour force living in the metropolitan area commutes to the other region. This indicates that the willingness to search for a job is higher in the rural area. Therefore, the base year is calibrated with a longer duration spell in the rural area.

The duration of an employment spell is calibrated to be shorter than OECD (1997). OECD reports that Denmark has an average employment spell of 8 years which is low compared to other OECD countries. Unfortunately, there are no regional data available regarding the duration of the employment spell and the average waiting time of the job openings. Therefore, it is chosen to fix them exogenous at the same level.

The average duration of an unemployment spell in the model is from 3.6 months to 8.5 months depending on the search strategy. In Denmark, an average unemployment spell is 3.9 months[2], but in the calibrated data it is higher.

The reason why the employment spell is calibrated shorter and the average unemployment spell is calibrated longer is that it is necessary with more incentive to search for a job in both regions. The unemployment spell works as a punishment for the worker if he does not search in both regions and this is needed to calibrate the number of workers who are commuting between the two regions.

Using numbers from 1995 the difference between the average commuting distances in kilometres inside the regions was less than one so it has been fixed at the same level. Also the two distances between the regions differ less than 5% so they have also been fixed at the same level. Besides the transport costs the workers have to pay for commuting, the workers also have less leisure time. In table 3.3 an accounting of the four types of commuters is presented.

[2] Measured in degree of unemployment in the year 1996, Statistical Yearbook (1997).

Table 3.3 Transport costs

	Residence and work in metropolitan area	Residence in metro-politan area and work in rural area	Residence and work in rural area	Residence in rural area and work in metropolitan area
<u>Transport costs</u>				
Distance in km	10	70	10	70
Price per km	0.75	0.675	0.75	0.675
Working days	200	200	200	200
Total excl. of tax	3,000	18,900	3,000	18,900
Tax	50 %	40 %	50 %	40 %
Total incl. of tax	4,500	26,460	4,500	26,460
<u>Time costs</u>				
Distance in time	20 min.	1 t 20 min.	20 min.	1 t 27 min.
Time value per hour	75	75	75	75
Total	10,000	40,056	10,000	43,623
Total transport costs	14,500	66,506	14,500	70,073

There is only one transport mode in the model so transport prices are a mix between the different transport modes which are used in Denmark. In The Danish Road Directorate (2001) the transport mode of Danish commuters is estimated. Around 60% drive car, 23% use train or bus, 7% are passengers in a car, and 7% are bicycling or walking. The choice of transport mode is assumed exogenous through this paper. Public transport is cheaper and less taxed than a car per kilometre. It is assumed that the train and driving as a passenger in a private car are used more on the routes between the two regions. Therefore are the transport price and the transport tax lower between the regions.

The commuters from the rural area to the metropolitan area have a greater time loss because of congestion on the roads. Please remember, that workers have different preferences of time costs. In table 3.3 it is the maximum time value per hour which is presented.

There is a local factor consuming sector in each region which produces the transport of commuters. Normally, it would be assumed that capital was used more intensively in the production of transport, but as mentioned the only factor input is labour. Table 3.4 presents the key figures in the sectors producing transport of commuters.

Table 3.4 Transport sectors

	From metro. area to metro. area	From metro. area to rural area	From rural area to rural area	From rural area to metro. area	Total
Production					
Transport quotient	0.01224490	0.07714286	0.01276596	0.08042553	-
Commuters	897,292	11,409	224,895	39,019	1,172,615
Total (= workers)	10,987	880	2,871	3,138	17,876
Transport costs					
Transport price	245,000	245,000	235,000	235,000	-
Total excl. of tax	3,000	18,900	3,000	18,900	-

The total production of transport can be calculated by simply multiplying the transport quotient with the commuters. The production function has constant return of scale and is scaled so that the total production equals the number of workers in the transport sectors. In the Danish national accounting system the transport sector share of the total employment is 4.8% (1996). Around 25% of the total transport is commuting, so a simple calculation yields that the number of workers in the transport sectors is 1.2% which is a little bit lower than 1.5% which the calibration results in.

The total transport costs were already presented in table 3.3, but it is the transport price and the transport quotient which enter the model. It is assumed that the exogenous transport quotient includes all distance factors including congestion.

The transport cost is just one of the expenses that the income must cover. There are six types of income groups in the model: Two regions multiplied three states on the labour market. The income in a given period and income group is named flow income which differs from the actual income of a given worker because he both experiences employment and unemployment via his participation in the labour market through time.

Table 3.5 Flow income

	Residence and work in metropolitan area	Residence in metropolitan area and work in rural area	Residence in metropolitan area. Unemployed worker	Residence and work in rural area	Residence in rural area and work in metropolitan area	Residence in rural area. Unemployed worker
Wage/unemployment benefit	245,000	235,000	80,000	235,000	245,000	80,000
Tax						
Marginal tax rate	65.28 %	65.28 %	51.59 %	65.57 %	65.57 %	52.44 %
Standard tax deduction	62,102	62,102	19,969	60,801	60,801	20,196
Tax deduction for commuting	0	24,000	0	0	24,000	0
Total tax	119,396	97,201	30,970	114,222	105,042	31.361
Income after tax	125,604	137,799	49,030	120,778	139,958	48.639
Transport costs	4,500	26,460	0	4,500	26,460	0
Income after transport costs	121,104	111,299	49,030	116,278	113,458	48,639
Profit income	6,056	6,056	0	6,056	6,056	0
Lump sum income	104,539	104,539	104,539	104,539	104,539	104,539
Total income	231,699	221,894	153,569	226,873	224,053	153,178
Maximum valuation of leisure loss if employed	10,000	40,056	0	10,000	43,623	0
Maximum valuation of place of residence	185,770	185,770	185,770	183,277	183,277	183,277
Total income incl. of maximum valuation of leisure and place of residence	407,469	367,609	339,339	400,150	363,707	336,455

The wage difference between the regions is understated if compared to a rough estimate of wage per worker from AKF's regional accounting system, but when factors such as educational level, sex, etc. are taken into account then the calibrated wage difference at 4.3% is probably a fine estimate. Compared to the wage per worker in AKF's regional accounting system the calibrated wage in the base year is around 20 percent higher. This has been done to calibrate the model better. It could perhaps be justified because some wage types such as royalties and some types of pension paid by the employers are not included in the definition of the wage in AKF's regional accounting system.

Total income inclusive and exclusive of maximum valuation of leisure and place of residence illustrates the two extreme values among the flow incomes. Most workers obtain a flow income in between because of the exogenous valuations of leisure and place of residence. The valuations are assumed to be uniformly distributed between zero and one. The worker will only obtain utility from one region so the regional valuation could be interpreted as a net valuation between the two regions. Furthermore, it is assumed that the share of the total population who has preferences for living in the metropolitan area is equal to the share of the regional labour force in 1995 who lives in the metropolitan area. This is not the same as assuming that the labour force lives in the preferred region in the calibrated steady state.

The lump sum transfers from the public sector are the same in the two regions. The regional profit is shared equally among all workers. The lump-sum transfers and profits cannot be compared with data outside the model.

When the regional incomes are compared it is also necessary to compare the price levels in the two regions. The commodity prices are the same in the two regions, but the difference is the level of housing prices. Remember, that the regional housing prices were determined by the regional wage. Therefore, the housing price is higher in the metropolitan area. Table 3.6 presents regional prices and how the total regional consumption is spent.

Table 3.6 Consumption

	Prices in billion DKK	
	Metropolitan area	Rural area
Commodities from the metropolitan area		
Consumption	641.2	157.6
Price	0.265	0.265
Expenditure	169.8	48.5
(% of total income)	(75.9%)	(75.9%)
Commodities from the rural area		
Consumption	183.1	45.0
Price	0.254	0,254
Expenditure	40.1	11.4
(% of total income)	(17.9%)	(17.9%)
Consumption of housing	56.7	16.9
Housing price	0.245	0.235
Expenditure	13,9	4.0
(% of total income)	(6.2%)	(6.2%)
Total regional income	223,793	63,916

Table 3.6 illustrates the total regional income is spend on expenditures. The preferences for commodites and housing are the same for all workers which are why the regional expenditure shares are regionally alike. The elasticity of substitution between the two types of commodities is 1.4 in the model and 1.0 for the elasticity between commodities and housing. The expenditure share of housing is modest, 6.2%, which does not reflect the actual expenditure of a typical worker. The starting point for the calibration of the housing sector has been the share of workers in the construction sector which was 6% in 1996. The housing sector is hereby calibrated from the production side of the economy.

Another way to illustrate the consumption composition is to describe the sectors which produce the consumption. The labour in the different sectors is presented in table 3.7.

Table 3.7 Number of workers in sectors

	Employed workers by place of work		
	Metropolitan area	Rural area	Total
Commodities	867,728	213,407	1,081,136
Housing	56,715	16,887	73,603
Transport			17,876
From metro. to metro. area	10,987		
From metro. to rural area	880		
From rural to metro. area		3,138	
From rural to rural area		2,871	
Total	936,311	236,304	1,172,615

It has been discussed how the sizes of the sectors have been determined.

The regional price indexes are presented in table 3.8.

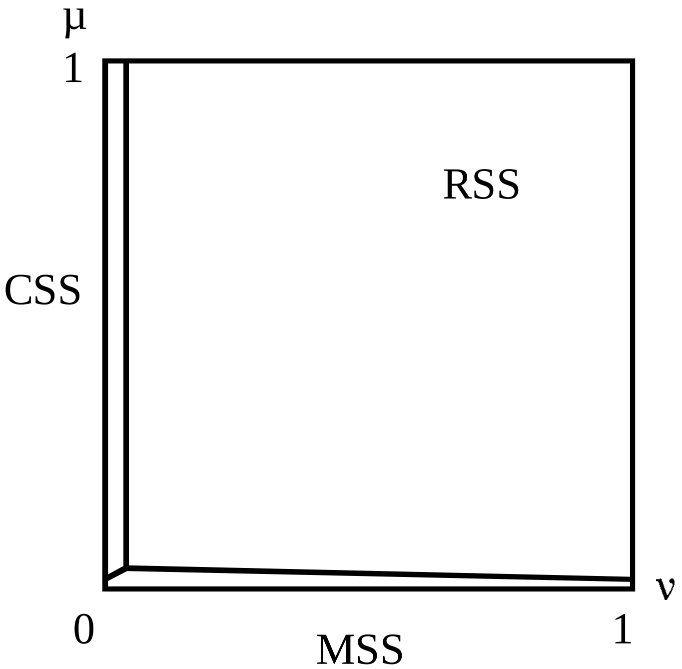
Table 3.8 Regional price index

	Metropolitan area	Rural area
Total price index	1.000	0.997
Price index of commodities	0.856	0.856

The difference in the total price index is because of the housing prices. The difference is, however, small because the share of the housing consumption is small.

Total income, the total price index, the valuation of leisure and residence, and the expected unemployment and employment spells are all factors which enter into the workers problem to choose an optimal search strategy. It is the expected present value of future utility which incorporates all these factors. In the calibrated steady state figure 3.1 illustrates the choices of search strategy for the workers who have preferences for living in the metropolitan area. μ is a uniformly distributed parameter which describes the degree of preferences for living in the given area whereas ν is the uniformly distributed parameter for leisure. The top right corner is a worker with maximum preferences for both place of residence and leisure whereas the bottom left corner is a worker with no preferences for both place of residence and leisure. The three lines inside the rectangle illustrate the values of the marginal worker who is indifferent between two strategies. It is assumed that the share of workers who prefer to live in the metropolitan area is equal to the number of workers living in the metropolitan area in 1996, namely 77.4% of the labour force.

Figure 3.1. Search strategy of the workers who prefer to live in the metropolitan area

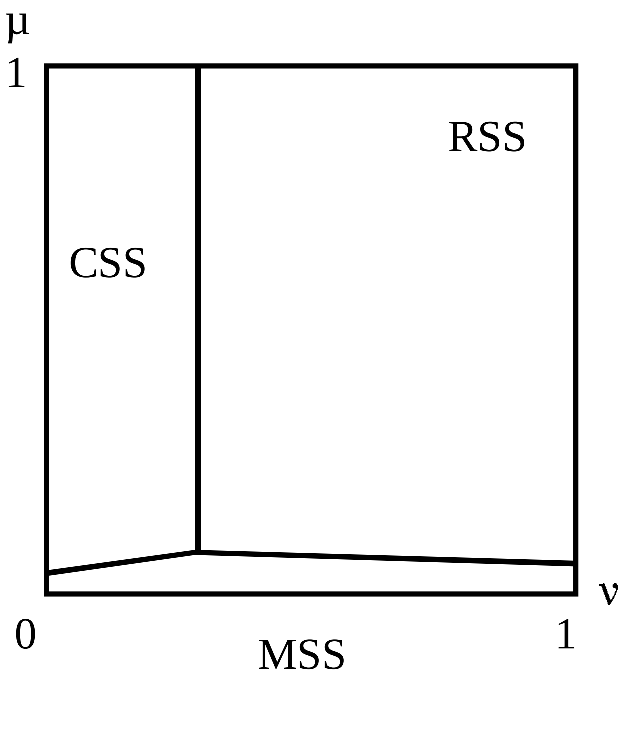


94.0% of the labour force with preferences for living in the metropolitan area chose the search strategy RSS while 3.0% chose CSS or MSS, respectively.

The number of moves between the metropolitan area and the rural area has been relatively constant for many years, and the net moves have been from the metropolitan area to the rural area from at least 1976. In the calibrated steady state the net moves are zero. In 1996 around 22,000 persons were moving between the two regions. The choice to move is typically not a one reason question and therefore it is not given how many of the 22,000 persons who have choice of work as an important parameter. The calibrated model yields 4,400 moving workers per year. Christensen et al. (1987) find that 9.8% of the Danish persons in the questionnaire tell that work-related conditions are the primary reason of the last move together with the wish to relocate. In a questionnaire survey in the Nordic countries, Nordisk Ministerråd (2002), 17.7% of the Danish persons tell that work relations are one of the motives of their last move. Only one out of six work-related moves was unemployed workers who got a new job which indicates that search on the job could be a useful model extension. When it is taken into account that it is only the labour force that is moving in the model the calibrated number of moving workers seems to be fair.

The picture is quite different for the workers who prefer to live in the rural area as figure 3.2 illustrates. 65.3% of these workers choose only to search in the rural area while 27.0% and 7.7% choose the search strategies CSS and MSS respectively.

Figure 3.2 Search strategy of the workers who prefer to live in the rural area



As discussed previously the willingness to search for job is larger in the rural area. One out of four is willing to commute because their valuation of leisure is sufficiently low, and some workers are also willing to move to the metropolitan area if the preferences for the rural area are sufficiently low.

The large share of workers choosing CSS results in commuters which cause externality costs. It is assumed that the workers do not consider externality costs when they choose their search strategy.

Table 3.9 Externality costs of commuting

	Intraregional commuting			Interregional commuting		
Area infected	Metro. area	Rural area	Both regions	Metro. Area	Rural area	Both regions
Costs in DKK per km						
Air	0.15	0.075	0.075	0.15	0.075	0.075
Noise	0.02	0.01	0.00	0.02	0.01	0.00
Accidents	0.12	0.10	0.00	0.08	0.07	0.00
Total	0.29	0.185	0.075	0.25	0.155	0.075
Total costs						
Km per commuter per year	4,000	4,000	4,000	14,000	14,000	28,000
Costs per commuter in DKK	1,160	740	300	3,500	2,170	2,100
Number of commuters	897,292	224,895	1,122,187	50,428	50,428	50,428
Share of car users	0.6	0.6	0.6	0.6	0.6	0.6
Total in million DKK	624.5	99.9	202.0	105.9	65,7	63.5

As mentioned the congestion costs are assumed to be part of the transport quotient while the maintenance costs of the infrastructure are part of the transport sectors. In The Danish Road Directorate (2002) the air pollution in the cities is estimated to be twice as high as in the rural areas. These estimates are used in table 3.9 with the extension that a quarter of the air pollution affects both regions. It is also assumed that the noise costs are highest in the metropolitan area. The accidents are differentiated with respect to interregional commuters because it is assumed that interregional commuters use the safer motorway more.

The total externality costs of commuting are presented in table 3.10.

Table 3.10 Total externality costs of commuting by place of residence

	Metropolitan area	Rural area	Total
Local externality costs in DKK per regional worker	734	569	
Global externality costs in DKK per regional worker	206	206	
Regional labour force	995,691	291,701	
Total in million DKK	936	226	1,161

4. The applied case of an improvement in the infrastructure between the regions

It is assumed in the model that there is no cost of implementing the improvement in infrastructure. The policy appraisal is therefore that the improvement should be carried out if the total gain could cover the actual cost of the new infrastructure.

It is assumed that it is only the connections between the two regions which are improved. Within the regions there is no improvement. The infrastructure investment is a hypothetical case of a general improvement in the transport conditions of commuters. For example the infrastructure improvement could be a new or improved motorway or/and a faster train connection. The reductions in the transport quotient and commuting time must of course be assessed explicitly when an improvement in the infrastructure is proposed.

The first improvement in this applied case is in the transport quotient. It is reduced if there are new connections, an improvement in technology, or a reduction in the congestion. Notice, there are no feedback mechanism in the model with congestion. All information regarding the congestion is in the exogenous transport quotient. The second improvement is a reduction in the commuting time of interregional commuters. Table 4.1 illustrates the experiment.

Table 4.1 Improvements in the infrastructure

	Metropolitan area to the rural area	Rural area to the metropolitan area
Reduction in the transport quotient		
Absolute	-0.00385	-0.00400
Relative	-5.0%	-5.0%
Reduction in the transport costs if the transport price was unchanged. In DKK.	943	940
Reduction in commuting time		
Relative	10.0%	10.0%
Time improvement in min. per trip	6.0 min.	6.7 min.
Maximum time saving in DKK per year	3,006	3,362

In the calibrated steady state there is more congestion from the rural area to the metropolitan area. It is assumed that the congestion decreases because of improved or new connections and therefore the reduction in the transport quotient and travel time is slightly larger from the rural area to the metropolitan area. Transport is, however, more expensive from the metropolitan area and because of that the reduction in transport costs is slightly larger in the metropolitan area.

If no model calculations were made the improvements in infrastructure could be assessed as if there were no changes in the commuting pattern, employment, prices, et cetera. Table 4.2 presents these directs effects.

Table 4.2 Direct effects of the improvements in the infrastructure

	Metropolitan area to the rural area	Rural area to the metropolitan area	Total
Direct effects			
Number of commuters	11,409	39,019	50,428
Reduction in transport time 1)	47	484	-
Reduction in transport costs in DKK	943	940	-
Total in million DKK	11.3	55.6	66.9

1) Average time valuation of intraregional commuters in the calibrated steady state in DKK.

The direct effect implies a total gain of around 67 million DKK if the intraregional workers' gains are summed up. It is chosen to impose the additive weight when totals are calculated. Decisions makers could have other weights. The additive weight is just this paper's choice of presentation.

An important implication of the direct effects is concerning the valuation of time. It is the workers with low valuation of time who commute between the two regions, and therefore there are relatively low gains with reduction of time between the two regions. Table 4.1 stated that the maximum gain of time saving was more than 3,000 DKK per year, but the gains are less than 500 DKK when it is taken into account that it is workers with low valuation of time who commute between the two regions. If more workers want to commute between the two regions it would be workers with higher valuation of time who are using the better infrastructure to increase their utility via a CSS.

5. Results of the applied case

An additive welfare function can be established to give a better overview of the results. When interpreting the regional welfare function it is important to remember that migration has an effect on the regional result because the defined welfare function add together the utility of the inhabitants living in the region. It is a question whether or not many inhabitants are desired or not. The welfare function is based on the regionally expected discounted utility and inhabitants in a given region could have discounted utilities from both regions because they also discount the possibility that they may live in the other region in some of the future periods.

When the welfare function is defined the equivalent variation (EV) can be calculated. EV is a measure of how much the population is willing to pay for the improvement in the infrastructure.

Table 5.1 Regional valuation of the improvements in the infrastructure

	Million DKK		
	Metropolitan area	Rural area	Total
EV	193.8	-78.3	115.6

The total gain of the additive social welfare function is 115.6 million DKK. It is only the metropolitan area that has a gain, but remember that the regional valuation is influenced by migration. EV is nearly twice as high as the direct effect in table 4.2 and this is because of derived effects within the model framework. Furthermore, the regional direct effects were higher in the rural area, but the regional EVs are indicating a different pattern.

The total valuation can be divided into four parts as presented in table 5.2. The total income, which can be consumed, is increasing. A small gain is obtained because the labour force live in the regions they prefer, but the transport investment results in less leisure and increasing externality costs. All together it is the result of more employed persons, but the gain is reduced by less leisure time and air and noise pollution together with more accidents on the roads because of more commuting.

Table 5.2 Total valuation of the improvements in the infrastructure

	Million DKK
	Total result measured in EV
Real income	321.3
Place of residence utility	7.8
Leisure	-117.7
Externalities	-95.8
EV	115.6

The flow utilities are only temporary states for a worker, but the development in a given flow utility tells whether or not the temporary state would be more or less attractive for the workers after the investment has been carried out.

Table 5.3 Development in flow utilities

	Changes in percent	
	Metropolitan area	Rural area
Place of work in the metropolitan area		
No utility of residence and leisure	+ 0.1 %	+ 0.7 %
Half valuation of residence and leisure	+ 0.0 %	+ 0.9 %
Full valuation of residence and leisure	+ 0.0 %	+ 1.1 %
Place of work in the rural area		
No utility of residence and leisure	+ 0.5 %	- 0.1 %
Half valuation of residence and leisure	+ 0.7 %	- 0.1 %
Full valuation of residence and leisure	+ 0.9 %	- 0.0 %
Unemployed worker		
No utility of residence and leisure	+ 0.0 %	+ 0.0 %
Half valuation of residence and leisure	+ 0.0 %	+ 0.0 %
Full valuation of residence and leisure	+ 0.0 %	+ 0.0 %

As expected there is a gain of the flow utilities of the commuters because these groups are benefited. It indicates that more workers will choose a CSS. There is decreasing utility of working and living in the rural area whereas most other flow utilities are increasing. This indicates that migration is not the only reason why the EV of the rural area is negative.

The results will now be described in more detail while the effects of the model are presented and weighted.

The experiment is to improve the infrastructure which implies that more workers choose a CSS. Workers choose CSS more because it is now cheaper to commute to the other area and the workers also save transport time. Firstly, it has the positive effect that the unemployment is reduced which implies increased production. Table 5.4 shows the effects on the labour market.

Table 5.3 Labour market effects

	Place of residence metropolitan area	Place of residence rural area	Total
Employed workers			
Place of production, metropolitan area	- 10,986	+ 11,535	+ 549
Place of production, rural area	+ 12,486	- 10,353	+ 2,133
Total	+ 1,500	+ 1,183	+ 2,683
Unemployed workers	- 1,202	- 1,480	- 2,683
Labour force	+ 298	- 298	0
Unemployment percent	- 0.1 % point	- 0.5 % point	- 0.2 % point

Secondly, as table 5.4 also presents, the labour force in the metropolitan area is slightly increasing by 298 workers which have migrated from the rural area. It corresponds to a decrease in the labour force in the rural area of 0.1%. Thirdly, relatively more workers are willing to commute from the metropolitan area to the rural region than the other way around. One reason is that more workers have preferences for living in the metropolitan area and other things being equal it indicates this interregional commuting development. This is not the only reason, because valuation of time and place of residence are not calibrated alike and because regional prices, taxes, lump sum transfers also influence the willingness to commute. With the described interregional commuting pattern, the relatively more workers in the rural area by place of production result in relatively larger production in the rural area. This indicates that the producer prices in the metropolitan area compared to producer prices in the rural area increase because of a relatively lower supply of the commodities from the metropolitan area.

The changed regional production prices are reflected in the regional wages. The regional wage in the metropolitan area divided by regional wage in the rural area is increasing by around 0.5%. The size of the unemployment benefit is a convex combination of the regional wages. Hereby, the unemployment benefit is decreasing compared to the wages in the metropolitan area, which is the dominating reason why the metropolitan wage is decreasing compared to the producer prices in the metropolitan area. Lower unemployment benefit compared to metropolitan wage is a worsen negotiation possibility when the regional wage is agreed. Also other effects such as regional taxes, regional commuting prices, and regional value of leisure enter into the wage negotiation. The opposite is the case in the rural area where the rural wage is increasing compared to the rural producer price. The profit rate defined by regional producer price over regional wage is hereby increasing in the metropolitan area and is decreasing in the rural area. An implication of this is that it is more attractive for the metropolitan firm to produce, which implies more job openings and following longer job opening spells in the metropolitan area. In other words, labour market tightness is increasing in the metropolitan area. On the other hand, it also implies shorter unemployment spells. However, these effects are small in the investigated case (less than one day), and therefore the results of the job openings and unemployment spells are not presented.

The commodity producing sectors are not the only sectors affected which table 5.5 shows.

Table 5.5 Sector effects

	Employed workers by place of work		
	Metropolitan area	Rural area	Total
Commodities	- 200	1,457	1,257
Housing	13	83	96
Transport			1,330
From metropolitan to metropolitan area	- 135		
From metropolitan to rural area	871		
From rural to metropolitan area		726	
From rural to rural area		- 132	
Total	549	2,133	2,683

The overall result in table 5.5 is that more workers get employed. Roughly half of them produce commodities and housing, but because the transport sector is factor consuming, half of the new employed workers produce transport in which there are no utility gains. It is the factor expensive commuting which increases and that is the reason why transport uses that much of the extra workers.

Minor effects on the total employment are due to the housing market. The regional housing prices are following the regional wage. Therefore, housing prices increase relatively more in the metropolitan area. The housing price effect is in the applied case at a sufficiently high level to dominate the income and migration effect which results in more housing in the metropolitan area. But the housing sector is increasing more in the rural region. If the model was reformulated with a short horizon fixed housing stock the housing prices would not be determined from regional wages, and the housing prices would increase relatively in the metropolitan area because of increasing income and labour force alone.

Larger effects on the total employment are due to the changed commuting pattern. More labour is needed to transport the workers both because of increasing production, but also because of longer total commuting distances. Regional commuting transport prices are also determined by the regional wages. This implies that the metropolitan area experiences relatively increasing transport prices. The transport price effects are minor compared to the change in infrastructure. The interregional commuters still benefit from lower transport costs compared to the intraregional commuters.

The main effect was as discussed above that more workers choose CSS. All the derived price effects described henceforth also affect the choice of search strategy. Lower housing price in the rural area attracts more workers to the rural area and this is also the case of cheaper transport prices in the rural area. On the other hand, an increasing wage in the metropolitan area persuades more workers to search for a job in the metropolitan area.

The result of the choice of search strategy is presented in figure 5.1 and 5.2.

Figure 5.1 Development in the search strategies of the workers who prefer to live in the metropolitan area

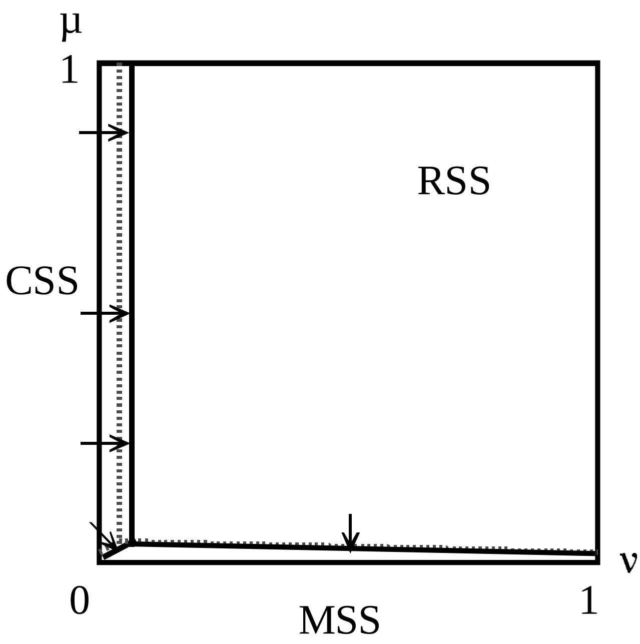
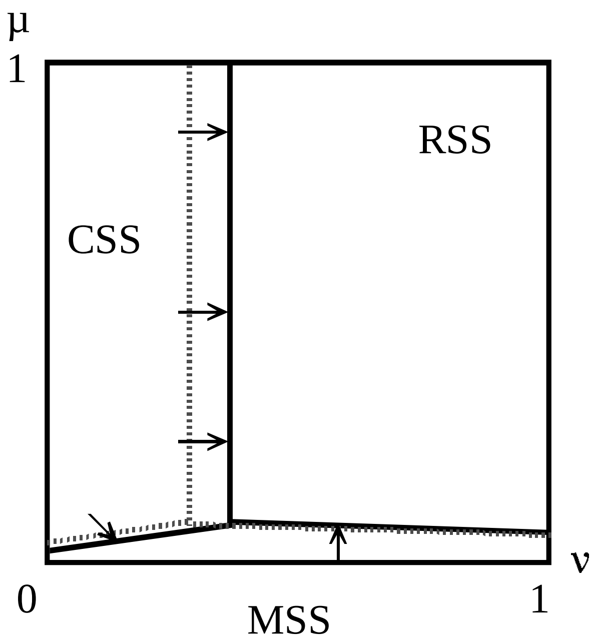


Figure 5.2 Development in the search strategies of the workers who prefer to live in the rural area



As the figures indicate the dominating effect in both regions is that the horizontal marginal line separating RSS and CSS is moving to the right. This is because the improved infrastructure makes it more favourable to commute. Almost 110% more workers choose the CSS strategy in the metropolitan area, and the increase is 30% in the rural area. RSS is decreasing by 3% and 12% and MSS is decreasing by 6% and 3% in the metropolitan and rural area, respectively. The increasing wage in the metropolitan area is moderating the tendency to more commuters, but the wage effect is not effective because the value of unemployment benefit is reduced in the metropolitan area. The higher wage in the metropolitan area also implies that fewer workers choose MSS even though the housing prices moderate this tendency. In the rural area the MSS strategy is influenced by two main sources. The higher wage in the metropolitan area is positively influencing MSS in the rural area, but more workers prefer RSS to MSS because of the better transport conditions.

To summarise this section, the dominating results are that more workers commute over longer distances and more workers are employed. The straightforward result that more workers commute over longer distances is covered in many analyses of infrastructure improvement, and the same applies to the positive employment effect, but this framework also yield a theoretical foundation of the modelling.

The model also gives the perhaps counterintuitive result that the economic activity is increasing in the rural area compared to the metropolitan area. It is mainly due to the calibration of the workers' preferences for leisure and place of residence and most important, the assumption that the present share of workers living in a given area corresponds to the number of workers who actually prefers to live in that area. Hereby, around three out of four are potential commuters from the metropolitan area to the rural area and only one out of four is a potential commuter in the other direction. Furthermore, the assumption of the uniform distribution of leisure and location is not empirically founded, and more information is preferred because it is a potential important matter.

The wages pull the results regarding commuters in the opposite regional direction because the relative regional wage is increasing in the metropolitan area. This implies that workers with RSS get money in the metropolitan area, and this is the main reason why the flow utility is increasing in the metropolitan area for a worker with RSS whereas it is decreasing in the rural area. This effect together with the fact that more workers move to the metropolitan area implies that the regional EV is increasing in the metropolitan area and decreasing in the rural area.

When interpreting the results of the model one should remember that general economic tendencies are not included in the model. For example, if the demand of high-tech commodities is continuing to expand it could benefit the metropolitan area because the metropolitan commodity is more high-tech intensive. This would move economic activity from the rural area to the metropolitan area and perhaps dominate the effects from better infrastructure. In other words, the results of the infrastructure improvement are only one part of the future economic development on Zealand – but it could have significant positive (and negative) influence.

6. Conclusion

Within the theory of this model improvements in infrastructure have positive effect on employment if the changes encourage workers to seek more active for a job. In the examined experiment it is the result, but the also negative effects enter the model. Emissions from commuters are increased simply through economic activity, but furthermore, commuting distances are increasing on average because it is the interregional commuting which is growing. The emissions are increasing and it is nearly halving the total gain of the new infrastructure.

The transport sector is using more labour to make the commuting possible. Half of the extra employed workers are hired in the transport sector which is a large amount for a support function. Still the extra labour needed and the emissions are not enough to reverse the gain of the new infrastructure. When costs of the infrastructure are introduced then emissions and more resources needed for transport could turn the point of balance between costs and benefits.

The regional effects are that it is the rural area which gets the economic activity. An important reason for this is that more workers from the metropolitan area are willing to search in the rural area also. The rural area does not benefit from the economic activity because the income is commuting back to the metropolitan area, but also because the regional wage is decreasing in the rural area compared to the metropolitan area. In addition there is a small migration towards the metropolitan area, which is interpreted as a welfare loss in the rural area.

The regional labour market reacts to changed regional profit rates which are increasing in the metropolitan area and decreasing in the rural area. This implies more job openings and shorter unemployment spells in the metropolitan area. The opposite is the case for the rural area. These effects are rather small in the experiment.

Because of the hypothetic setup in this paper no specific policy could be recommended. However, by using the model in this paper, consequences from transport investments on the labour market and the economic activity can be evaluated more thoroughly. Such analyses must be important inputs in the decision-making process.

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