

Chapter 6

An economic geography approach to evaluating a new Dutch railway link

6.1 Introduction

In May of the year 2000, the Dutch government commissioned a research project into the economic effects of a major infrastructural project involving the construction of a rail link between Amsterdam and the north of the country. The region around Amsterdam¹ is clearly the economic center of the Netherlands: 42% of employment and more than 48% of GDP is produced on an area that is no more than 15% of the country's total. Quite the opposite, the north of the Netherlands² is considered an economic laggard with 11% of GDP and 8% of employment on 27% of the country's area. Attempts to jump-start the northern economy with large subsidies and the forced relocation of government-owned companies so far have failed. The unfulfilled potential is aptly illustrated by relatively high unemployment rates and the swift return of the once-relocated companies to the West.

The construction of a government-sponsored rail link between the West and the North is thought to remedy this problem. Arguments in favor of construction center around the indirect effects of such a link. Of these there are two, external to the train's operator, that could benefit the country as a whole. The first effect concerns the commuting behavior of workers in the

¹The statistics pertain to what is called the 'Randstad,' comprising metro Amsterdam, the province of Utrecht and the province of South Holland including metro Rotterdam. We will use the terms *Randstad*, *the West* and *the Economic Center* interchangeably in this paper. GDP statistics come from RuG/CBS (1999) p. 16, others from the 1998 LISA database.

²Although the north of the Netherlands is quite diverse, the term is usually reserved for the combination of the provinces Friesland, Groningen and Drenthe. These provinces have allied themselves in a bid for economic support from the central government.

West. With a fast rail link, they could relocate to the North while keeping their current jobs. The incentive to move comes from the relatively low prices of northern real estate as construction in the West reaches its natural limit. The decrease in pressure on the Western housing market would be considered a national benefit. This effect is explored in a parallel paper contained in Oosterhaven et al. (2000).

The second effect concerns the changes in economic activity that can be brought about by the link. Many companies that start in the North eventually move to the West, quoting their desire to be close to other companies (mostly those that deliver services, like advertising agencies and legal firms) as a reason for leaving. This desire is strong enough to overcome the higher prices of property, the tighter labor market and greater congestion of the West. With a rail link in place, the price of these services to firms located in the North would be lower, possibly shifting the balance in favor of location outside the center. Such induced activity is seen as the key to further economic development.

In this paper, we will explore the second effect using a Computable General Equilibrium (CGE) model of the Netherlands. The model fits in the New Economic Geography line of research and builds on a concept introduced by Venables (1996b). The basic structure resembles a similar model developed for the European Union by Bröcker (1999). The model is more detailed, however, introducing fourteen different sectors and their input-output linkages.

The effects that are captured by this kind of model lend themselves to an explanation in terms of forward and backward linkages (Hirschman 1958). A reduction in transport costs generally leads to a lower price of products consumed far from their producer. This leads to an increase in demand for this producer, which is an example of a backward linkage. Because the cheaper product can again be used as an intermediate input by local producers, they in turn can reduce *their* prices: this is an example of a forward linkage. Because we use local IO tables and detailed information about the effect of the rail link on travel times, we can track effects through the economy and derive detailed welfare effects.

An important part of the data that is used in the construction of this model is taken from the bi-regional input-output tables (RUG/CBS 1999) in which the economic ties between Dutch provinces are detailed. Some of the model's parameters come directly from this publication; others are estimated by fitting trade flows predicted by the model to flows observed in the tables. Special care is taken with respect to the spatial structure of the model: we discern between the transport of goods and people and in the latter case discuss the role of public transport.

This chapter continues as follows: in Section 6.2, we discuss relevant economic theory and the specification of the model. Estimation of the parameters and calibration of the model is done in Section 6.3. Section 6.4

discusses the project alternatives and shows the results of simulations. We evaluate the model in Section 6.5, where we attempt to quantify the uncertainty of the analysis and point out obvious weaknesses. Section 6.6 concludes.

6.2 The Model

There exist several models that explain spatial patterns of production by increasing returns to scale and positive transport costs. In these models, agglomeration is caused by the desire to overcome transport costs when selling ones product or making purchases. This similar desire on the side of producers and consumers leads to a feedback loop, resulting in self-enforcing agglomeration. The precise form of this loop differs between models.

We use a specification introduced by Venables (1996b) where firms use both labor and intermediate goods in production. Workers are not allowed to relocate, but firms enter and leave the market according to profitability. For some parameter values, a situation where most activity is located in one place is stable: the attraction for firms consists of the low price of intermediate goods and is self-enforcing.

We modify this model on several counts. Different sectors are introduced, leading to a richer set of possible outcomes (the effects of different sectors in these models are explored in Knaap, 2000). The labor market is simplified, so that it is in line with Dutch reality. Transport costs are differentiated according to what exactly is transported.

In the following sections, we use the convention that there are fourteen sectors indexed by s . The country can be divided in fourteen major regions (twelve provinces and two metropolitan areas) indexed by p , in forty COROP regions indexed by o or in 548 communities indexed by c . A full description of this convention, and the available data on each level, can be found in Appendix 6.A.

6.2.1 Production and Utility

Specification

Utility of a representative consumer in province p is given by

$$U_{i,p} = \prod_{s=1}^{14} U_{i,sp}^{\theta_{sp}} \quad (6.1)$$

where

$$U_{i,sp} = \left(\sum_{c=1}^{548} n_{cs} X_{i,cs}^{1-1/\sigma_s} \right)^{\frac{1}{1-1/\sigma_s}}. \quad (6.2)$$

with X_{cs} the level of consumption by person i of a sector s -product from community c . As it turns out that all firms from a certain community in the same sector use the same price, the number X_{cs} holds for all those firms. The number of firms in community c that are in sector s is given by n_{cs} .

As seen above, utility is computed in two stages: first, according to (6.2), sub-utility within each sector is computed by aggregating purchases from all communities. This aggregation is done by a CES function, indicating that the firms within a sector are in a state of monopolistic competition (Dixit and Stiglitz 1977). The size of the different $X_{i,cs}$'s depends on the price of the product and the sector-specific elasticity of substitution σ_s . Sectorial utilities $U_{i,sp}$ are combined using the Cobb-Douglas function (6.1). This specification implies that each sector receives a fixed share of the consumers' budget.

As appears from this specification, we allow for different utility functions in different parts of the country: each major region has its own set of utility parameters Θ_p . While it is unclear if regional peculiarities of this kind are a stable phenomenon, this specification allows us to take parameters Θ_p directly from the bi-regional IO tables: they are simply the share of the consumer budget devoted each sector. Assuming that each region described in the tables has its own preferences is a convenient short cut that nonetheless has its price: a higher share of the budget devoted to a certain sector could also indicate a lower price of those products in a certain region, possibly due to transport costs. While recognizing this problem, we employ the specification in (6.1) for the sake of simplicity.³

On the production side, we assume that firms face the following production function:

$$Y_{j,ps} = c_{ps} L_j^{\alpha_{ps}} Q_j^{1-\alpha_{ps}} \quad (6.3)$$

$$Q_{j,ps} = c'_{ps} \prod_{s'=1}^{14} Q_{j,s'}^{\gamma_{p,s,s'}} \quad (6.4)$$

The production of any firm j is thus a Cobb-Douglas aggregate of used labor L_j and intermediate goods Q_j . The parameter α_{ps} of function (6.3) varies per sector and per major region. It is computed from the bi-regional IO tables: $1 - \alpha_{ps}$ is the share of intermediate products used in production. The sector-region specific constants c_{ps} and c'_{ps} allow us to use a simple form for the cost function later on. Derivations of these constants are in appendix 6.B.1.

The intermediate good itself is an aggregate of goods and services from all fourteen sectors, as is shown in formula (6.4). Once again the aggregation is of the Cobb-Douglas variety, with parameters $\gamma_{p,s,s'}$ taken directly from the IO tables.

³The variance of θ_{sp} over p around the average θ_s was typically around 5% of the θ_s .

On the sectorial level, we assume monopolistic competition. So, while the input share of a certain sector may be a constant γ , the actual producer that is chosen to supply the input is dependent on the price. This is a very appealing assumption, as in reality parameters like γ are often dictated by technical constraints, but within these constraints the producer is free to shop around for the cheapest supplier. The specification of $Q_{j,s}$ is identical to that of sectorial sub-utility in formula (6.2):

$$Q_{j,s} = \left(\sum_{c=1}^{548} n_{cs} X_{j,cs}^{1-1/\sigma_s} \right)^{\frac{1}{1-1/\sigma_s}}. \quad (6.5)$$

In this specification, it is essential that producers and consumers share the same elasticity of substitution σ_s . This way, the demand curve from both parties is identical and the optimal price for the supplier is the same, regardless of the type of customer. It also implies that we can use the same price index for both producers and consumers. Different values of σ_s would make the model much more complicated and are not considered in this paper.

Solution

The standard Monopolistic Competition results (MC hereafter) hold in this model, leading to familiar, if somewhat elaborate, expressions for demand and supply. Consumers and producers both exercise demand. If we look at a consumer in community c , major region p with income w , her demand for a certain product from producer j in sector s' , located in community c' will be

$$D(p_{j,c',c,s'}) = w \cdot \theta_{s',p} \cdot \frac{p_{j,c',c,s'}^{-\sigma_{s'}}}{G_{c,s'}^{1-\sigma_{s'}}} \quad (6.6)$$

with the price index defined by

$$G_{c,s'} = \left(\sum_{c'=1}^{548} n_{c',s'} \cdot p_{j,c',c,s'}^{1-\sigma_{s'}} \right)^{\frac{1}{1-\sigma_{s'}}}. \quad (6.7)$$

Similarly, demand from a producer in sector s , community c which is in major region p , who spends wL on labor, will demand from producer j

$$D(p_{j,c',c,s'}) = wL \cdot \frac{1 - \alpha_{p,s}}{\alpha_{p,s}} \cdot \gamma_{p,s,s'} \cdot \frac{p_{j,c',c,s'}^{-\sigma_{s'}}}{G_{c,s'}^{1-\sigma_{s'}}}.$$

Notice that, as usually in MC models, a positive quantity is demanded from *each* producer, no matter how high the price (and no matter how far

away). This may cause a problem later on as many products in real life are not suitable for transport over long distances.⁴ We will return to this problem in Section 6.3.2.

6.2.2 The Labor Market

One of things that sets this model apart from that in Venables (1996b) is the specification of the labor market. Usually a completely inelastic labor supply is assumed, where a given amount of labor is always employed and the wage is computed as the closing variable of the model. Wage differences lead to marginal cost changes and to price differences between regions, which is an important step in the model's final results.

We feel that such a competitive wage-setting environment does not accurately reflect the situation in the Netherlands. Wages are negotiated on a national level and thus are not different between regions. This has several repercussions: first, there are no incentives to migrate between regions in order to receive a higher nominal wage. Second, local labor markets do not always clear. Unemployment is prevalent in those regions where excess labor supply exists. The unemployed nonetheless are able to exert demand, the same way the employed workers do, through unemployment benefits.

Therefore, the labor market is modelled as quantity-oriented and demand controlled. We assume that the wage is equal throughout the country and set it to 1. Any shocks in labor demand are absorbed by hiring or firing workers, implicitly assuming that there are no constraints in labor supply: each community has a sufficiently large pool of unemployed to use in times of increased labor demand.

We model the effect of income taxes and unemployment benefits in an even cruder way: all incomes are taxed at a rate of 100% and then redistributed to all inhabitants. This implies that the consumer income in any community is proportional to the number of inhabitants. Because we do not model the labor supply decision, this rather unorthodox taxation scheme does not have an impact on the supply of labor.

6.2.3 Transport Costs and Prices

Specification

It is customary in models of this kind to let transport costs take the form of leakage: a certain fraction of the transported product is lost along the way, the size of the fraction determined by the distance travelled. By incurring

⁴The result that a positive quantity is demanded from each producer regardless of the price (indicating an indispensability of each product variety) does not necessarily follow from the assumptions underlying monopolistic competition, but rather from the iso-elastic demand function that we have assumed. It occurs usually in MC models the sense that this type of demand function is usually employed.

transport costs in the product itself, there is no need to explicitly model a transport sector and prices can easily be adjusted for distance.

We modify this *iceberg approach* to account for the fact that there are two types of transport, and the new infrastructure will change only one of those types. Transport of goods is assumed to be unaffected by the new link, as it takes place mostly by truck, ship or pipeline. Passenger transport on the other hand, the second type, is definitely affected by the new link.

We compute transport costs as follows: in general, transport causes a markup on the price of a product, depending on the distance d that is travelled, equal to

$$f(d) = 1 + \nu d^\omega. \quad (6.8)$$

Depending on the sector s to which the product belongs, a share π_s is goods transport and a share $1 - \pi_s$ uses passenger transport. The total transport markup thus is equal to

$$\begin{aligned} \tau_s(d) &= [f_g(d)]^{\pi_s} \cdot [f_p(d)]^{1-\pi_s} \\ &= [1 + \nu_g \cdot d^{\omega_g}]^{\pi_s} \cdot [1 + \nu_p \cdot d^{\omega_p}]^{1-\pi_s} \end{aligned} \quad (6.9)$$

Distance for goods transport has been measured in kilometers. The distance for passenger transport is measured in minutes and is computed an average between public transport time and driving time (for these two variables, see also Section 6.A.2). The parameters ν_i and ω_i are estimated in Section 6.3. Parameters π_s have been obtained exogenously and are specified in Section 6.A.3.

Solution

The marginal costs for firm j , which is in sector s , community c and region p are equal to

$$\text{MC}_{s,c,p} = w^{\alpha_{ps}} \cdot \tilde{G}_{cs}^{1-\alpha_{ps}} \quad (6.10)$$

where the price index of intermediate goods \tilde{G}_{cs} is defined as

$$\tilde{G}_{cs} = \prod_{s'=1}^{14} G_{c,s'}^{\hat{\gamma}_{p,s,s'}}$$

with the price index for sector s in community c , $G_{c,s}$, defined above in formula (6.7).

The optimal price for the above firm is, as usual in MC, a markup times the marginal costs:

$$p_{j,s,c} = \frac{\sigma_s}{(\sigma_s - 1)} \text{MC}_{s,c,p} \quad (6.11)$$

This gives the price $p_{j,s,c}$ which holds in community c in which the firm operates. The price in another community c' is found using the specification

of transport costs above:

$$p_{j,c',c,s} = \tau_s(d_{c,c'}) \cdot p_{j,s,c} \quad (6.12)$$

where $d_{c,c'}$ is the distance between the two communities.

6.2.4 Computation

The actual computation of the price that a company charges for its product in a given community is fairly complicated. As follows from (6.10), each price is a function of local wage (which is zero, by definition) and the local price index of intermediate goods. This price index depends on the price of nearly every other available good in the country, as well as transport costs for all these goods. In turn, these prices each depend on all other prices and applicable transport costs. The equations that describe these pricing decisions⁵ cannot be solved analytically. In practice, a numerical procedure is used where all prices are set to one and the system is allowed to iterate until convergence. This presupposes knowledge of the parameters ν_i , ω_i and σ_s . Those parameters have been estimated - that procedure is detailed in Section 6.3. It also presupposes knowledge of the number of firms $n_{c,s}$ in each sector in each community. As it turns out, the number of firms in a community is proportional to the product of α_{ps} and $L_{c,s}^{total}$. The latter is the amount of labor that is used by the sector in that community, both are a known variables. The proof of this is deferred to appendix 6.B.2.

6.3 Estimation and Calibration

6.3.1 Procedure and Data

In the previous section, we specified the model and pointed out where the data came from and how we found the model's parameters directly from the IO tables. That is, up to eighteen unknown parameters that we will estimate in this section. We will call this set of parameters Γ , and they are

- the fourteen elasticities of substitution σ_s , each particular to a specific sector.
- the parameters of the two transport cost functions, ν_i and ω_i ($i \in \{g, p\}$).

We will estimate these parameters in the following way: for any given set of values for the unknown parameters, we can use the model to compute the demand that is exercised by each region upon every producer in

⁵In effect, formulas (6.7) and (6.10) through (6.12).

the country. Adding a subset of these numbers in an appropriate way, we can compute any flow of trade in the country, given that we have a set of parameters Γ .

For instance, we can compute the demand for agricultural goods exercised by consumers and businesses *inside* the province of Utrecht, upon suppliers that are located *outside* this province. This would be an intensive computation: we would have to establish prices for all goods, compute the amount of money allocated to agricultural goods in each Utrecht community, and use prices and transport costs to divide this budget between agricultural producers in all 548 communities. Then we would have to compute how many goods each budget will buy, add up all the goods bought outside the province, and sum over all buying agents inside Utrecht. This is of course a tedious task, which can fortunately be left to the software implementation of the model. Once it is done, we have replicated two entries from the bi-regional IO table of Utrecht: the flow of agricultural goods from outside the province into the province, used as intermediate good and used as consumption good.

The number of trade flows that can be lifted from the IO tables is, in principle, equal to 11,760. There are fourteen bi-regional tables; each gives four sets of flows: *from* inside and outside the region *to* inside and outside the region. Each set consists of a fourteen by fourteen matrix with flows of intermediate goods and fourteen flows of final goods.⁶

We will estimate the parameters by trying different sets of Γ and finding the one that minimizes the sum of squared differences between the predicted (log-)flows of goods and the (log-)flows in the IO tables. The logarithms are used so that the larger flows do not dominate the estimation. For several reasons, we do not use all the available data, both discarding some flows and summing to aggregates.

First of all, the data regarding flows *from* outside a region *to* outside a region are discarded. The reason for this is that the quality of the data is thought to be poor; it is constructed by as a rest-category subtracting the other flows from a total. This also creates a redundancy in the data, as the same totals are used again and again.

We aggregate the rest of a data because of two reasons: first of all, computational restrictions limit the number of data points that can be digested in a reasonable time. Because we need to find an optimum over eighteen parameters, the computation involving a single set G cannot take too long. Secondly, many flows are insignificant and measured with a large error. For example, the mining sector in the reclaimed-land province of Flevoland is virtually non-existent, leading to very small trade flows which contain no useful information. Using this data in logarithms would contaminate our set.

⁶To make matters confusing, there are fourteen regions and fourteen sectors.

So, we sum observations until we are left with 588 datapoints: for each of 14 regions we have the sales of each of 14 sectors, to customers inside the own region (both final and intermediate) and to customers outside the region. For each of 14 regions, we also have 14 values giving the purchases from outside the region per sector. We will match these 588 datapoints with those predicted by the model.

6.3.2 Problems with the estimation

Transportability

Within the model as we have described it so far, the consumption decision is based on prices, which in turn are the result of transport costs. A strong preference for local goods thus can only be explained by very high transport costs. As it turns out, for some sectors the preference for local goods is so strong that it would imply incredibly high costs of transport. For instance, in our measured year consumers in the province of Utrecht spent 1749 mln guilders on education. Almost 92% of these expenditures were made *within* the own region, which produces only 9% of the country's educational output. Clearly, if price was the only issue, transport costs would be immense. There seems to be something in the nature of education that makes it less suited for trade.

So far we assumed in our model that there are no non-tradeables. To allow for these, we introduce sector-specific parameters that measure *transportability*. Obtained from the regional balances of goods (RUG/CBS 1999), these parameters indicate the degree to which output can only be produced on the spot, because it is over-the-counter or personal. The parameters are exogenous to the model and given in appendix 6.A.3. In our model, we account for transportability by dividing expenditures on each sector into expenditures on non-tradeables and expenditures on tradeables using the new parameters.

Identification

In related work, Bröcker (1999) found that the estimation of the parameter set Γ suffers from the problem that the parameters may not be separately identifiable. He proves that for a slightly different transport cost function, which nonetheless resembles the one in (6.8), parameters are not identified at all.

The problem is quite intuitive: increasing the costs of transport or increasing the elasticity of substitution has exactly the same effect: more local goods will be consumed, either because imported goods become more expensive or because the (cheaper) local goods can be more easily substituted for (more expensive) imported goods. This leads Bröcker to use extra data

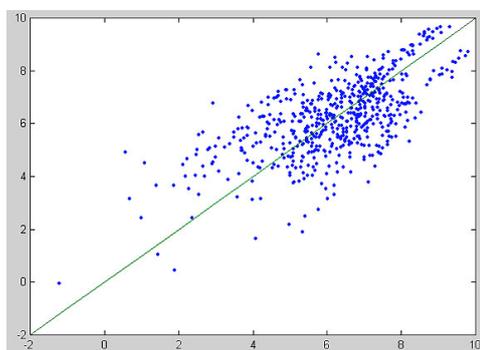


Figure 6.1: This plot shows the ability of our model to predict the flows of trade. Each point represents a flow—the x -coordinate is the predicted flow, and the y -coordinate is the actual flow. Both are in logs. Perfect prediction would mean that all points lie on the 45° line, which is also drawn.

about the importance of transport costs in final good prices in his estimations.

We have found that our model suffers from the same problem, in the sense that the search for optimal parameters seems to take place in a lower dimensional subspace of the parameter space. Nonetheless, we found an optimal constellation of parameters which were within reasonable bounds, given other estimations of this kind (for instance Bröcker 1999, Hanson 1998), for instance).

6.3.3 Estimation results

The parameters that minimize the sum of squared errors are in table 6.1. The graph in figure 6.1 shows the goodness of fit of the estimation. The (log) flows of trade as predicted by the model are on the horizontal axis, the actual (log) flows of trade are on the vertical axis. a 45° line is drawn.

Parameter	Estimate	Parameter	Estimate	Parameter	Estimate
σ_1	11.1	σ_8	23.6	ν_g	0.006
σ_2	8.3	σ_9	8.2	ω_g	0.770
σ_3	12.5	σ_{10}	13.7	ν_p	0.010
σ_4	16.4	σ_{11}	14.2	ω_p	0.593
σ_5	24.0	σ_{12}	12.2		
σ_6	15.1	σ_{13}	12.5		
σ_7	29.8	σ_{14}	18.7		

Table 6.1: Estimates of the unknown parameters Γ as obtained from a non-linear least squares procedure

Many of the estimated parameters are much higher than those measured in chapter 5. This is not unusual; Hanson (1998), for instance, measures $\sigma = 10.4$ for United States counties. At face value, these results do seem to imply that many markets are close to perfectly competitive.

So far, we have used the wage as a numéraire. This means that all values inside the model, including the predicted flows of trade, are denoted in terms of w . During the estimation, when we must compare the predicted flows of trade with actual numbers denoted in millions of guilders, we must convert our internal figures. This is done by multiplying them by a factor so that, on average, the prediction is correct. This procedure is equivalent to estimating an intercept in figure 6.1. This factor, or the intercept, is in turn an indication for the actual value of our numéraire, the wage level w . We find an intercept of -2.55 which indicates an average wage of 77.9 thousand guilders. This is surprisingly close to the actual figure, which is 79.2 thousand for our measured year.

With the numbers in table 6.1, we can do some back-of-an-envelope calculations about the effect of distance on demand. We use a typical elasticity of substitution $\sigma = 12$ to compute at which distance half of wholesale is lost because of transport costs. For this distance $d_{1/2}$, there must hold that

$$\frac{1}{2} = \left(1 + \nu_i \cdot d_{1/2}^{\omega_i}\right)^{-(\sigma-1)}, \quad i \in \{g, p\}. \quad (6.13)$$

Using this formula, we compute that a customer who would buy 1 guilder's worth when the supplier would live next door, buys exactly 50 cents' worth from the same supplier when the distance between them is 21 kilometers and all hauling involved is goods transport. Similarly, if all transport is of the passenger kind (*i.e.* the supplier must meet the customer in person) the potential wholesale is halved every 22 minutes.

6.3.4 Calibration

We now have the complete set of parameters, estimated using data from the 1990s. The aim of our model is to evaluate the impact of certain infrastructural changes in 2020. To be able to do this, we calibrate the model to a dataset that describes the situation in 2020 if none of the proposed projects is carried out. This dataset consists of the travel-times between all Dutch communities based on the projected state of public transport in 2020 (NEI/HCG 2000; the so-called *reference matrix*) and the projected number of jobs in each community in each sector in 2020 (TNO Inro 2000). We call this set the null-alternative; it is constructed exogenous to the model by based on economic scenarios from the CPB and known plans to upgrade infrastructure. More information about the different scenarios is in appendix 6.A.2.

Given the parameters, the amount of labor used in each sector in each community, and the matrix of transport times we can compute supply and demand for each sector in each community in 2020, in the null scenario. Unfortunately, given that the data in the null-scenario come from outside our model, there is nothing that guarantees the equality of supply and demand at this low level. Yet, to start out with a balanced model we must somehow equate the two. This prompts the introduction of a class of 'offset' variables, which take the value of demand minus supply for each sector in each community. We now redefine supply as the number computed with our model *plus* the appropriate offset variable.

One of the interesting figures concerning the implementation of a certain project will be the change in the number of jobs that ensues. Using the above patch, we can compute this number: the change in transport costs will give the change in demand; matching (the redefined) supply to this change in demand using formula (6.3) gives the needed amount of extra labor. The use of extra labor in turn triggers new demand effects that make their way through the economy.

6.4 Simulation Results

6.4.1 Some remarks

We evaluate five scenarios that are alternatives to the null-scenario to which we have calibrated our model above. The only difference between these scenarios and the null-scenario is in the matrix with travel-times. In each scenario, a different infrastructural project has been implemented and the changes in travel-time between each set of two communities has been computed. These computations are done outside our model by NEI/HCG (2000). Details are in section 6.A.2.

When we run our simulations, there are two more factors which we must take into account. First of all, while this study is concerned with the Netherlands as a closed country, we feel uncomfortable letting all the extra demand generated by the changes in the economy be absorbed by domestic producers. That is why we only let 50% of the extra demand come to bear on the Dutch market, letting the other half leak out of the country. As it turns out, this measure does not have a large impact because the *extra* demand is very small; it is the distribution of demand that changes the most.

Secondly, we take account of a third sector-specific exogenous characteristic, *exogenous ties*. With this parameter, we incorporate the fact that for some companies, the choice of location and level of activity is wholly independent of prices, as they are tied to their location and their customers are tied to them. This can be because of localized natural resources or because

of a fixed local clientèle, as in the case of municipal governments. The parameter gives the share of companies for which changes in price (as a result of changes in transport costs) does not alter their scale of operation, except for sector-wide changes in demand. For instance, the a municipal government which is 100% tied to its location and customers, does not sell any more or less because of changes in transport costs. However, if the changes lead to a smaller demand for *all* government services this does affect the municipal government. More on this parameter can be found in appendix 6.A.3.

6.4.2 Endogenous number of varieties

We encounter a severe problem during the first attempts to simulate a new equilibrium with the model. This problem is the result of our specification of the labor market, which was detailed in section 6.2.2. There, we assumed that there exists an infinite supply of labor at each location at the present wage. The labor market is demand-constrained and is characterized by positive unemployment in all locations. This assumption followed from the fact that the wage is not thought to be a regionally differentiated variable in the Netherlands.

However, as it turns out, the model has become unstable because of this assumption. The instability works as follows: if at a certain location demand is increased, the number of jobs and hence the number of firms goes up (formula 6.17). With the new firms, new varieties are introduced which lead to a new increase in demand and a new increase in the number of jobs. Because of the infinite supply of labor at unit cost, this process becomes explosive. Table 6.2 shows the dynamics of such a run. We evaluate the MZB scenarios and for two cities, we give the change in the number of jobs after each iteration of the model. While Almere, situated along the new line, grows explosively the more peripheral city of Eindhoven loses all its employment.

	1	2	3	4	5	6	7
Almere	2063	3757	5417	7305	9691	12931	17448
Eindhoven	-5	-43	-105	-188	-293	-423	-591

Table 6.2: The change in employment in two cities after a project, in seven iterations of the model. The number of firms varies endogenously.

To stop the model from exploding the way it does in table 6.2, we leave the number of firms fixed during simulation runs. This means that our analysis only picks up effects that relate to the redistribution of demand as a result of the new prices, and to the fact that less product is wasted in transport. Effects that come about because of an change in the number of

varieties at certain locations are no longer part of the analysis.

6.4.3 Figures

We evaluate five possible scenarios involving infrastructural projects and compare them to the reference scenario in which only planned improvements to infrastructure are made. The scenarios are in appendix 6.A.2. For each scenario, we compute a new equilibrium of supply and demand, given the changed costs of transport. Each equilibrium is characterized in two ways:

1. We compute the change in the number of jobs in each of four regions. We take the two regions that are supposed to benefit most, the West and the North, the Flevo region through which most of the lines go, and the rest of the country. By aggregating the results for individual communities to this level, we hope to average out part of the error and show the result for regions that are politically interesting.
2. The infrastructural projects lead to a change in prices for each community, as services from far away get cheaper. Looking at the local price index allows us to compute a welfare effect of the project: the increase in utility that is achieved in a community by the lower local price index of consumption could also have been brought about by raising in municipal income with a certain amount of money. The sum of those equivalent increases in income give an indication of the welfare effect of the project.

	HIC	HHS	ZIC	MZB	MZM
North	634	1798	906	3496	3077
West	239	417	1185	2150	2503
Flevo	368	622	396	2075	2455
Rest	-1256	-2887	-2523	-7796	-8078

Table 6.3: Change in the number of jobs per region after each of five project alternatives

	HIC	HHS	ZIC	MZB	MZM
Δ CPI (in %)	-0.02	-0.06	-0.02	-0.09	-0.09
eqv. Δ GDP (mln95DFI)	141.6	344.7	124.1	577.5	553.5

Table 6.4: Change in the price index of consumption for the average consumer

The first results, the change in the number of jobs, are in table 6.3. We see that, as expected, the regions at the ends of the line are the biggest winners: both the North and the West gain the biggest number of jobs. Both regions experience an increase in demand (from each other) and a decrease in the price of intermediate goods, leading to higher order effects. If the schedule calls for frequent stops along the way, the middle province of Flevoland also shares in the gains. The rest of the country pays the price, though. Because the effect is largely redistributive (products from easier-to-reach regions become more popular vis-à-vis products from other places) the jobs that are gained in the North and the West are lost in the rest. Six maps with an indication of the geographical spread of these results are drawn in figure 6.2 on page 179.

The numbers in table 6.4 show that lower costs of transport lead to a lower price index of consumption for the average consumer. This is to be expected: since transport costs, which are a pure loss in the model, decrease everybody is better off. The assumption that we made about the redistribution of income implies that this is literally true for everyone, even those living in the regions that loose jobs. While the percentage-point figures in table 6.4 are not very impressive, the amount of money that is needed to create an increase in GDP with a comparable effect on utility is quite large.⁷

6.5 Evaluation

The study in this paper is part of a larger effort to gauge the most important effects of the infrastructural projects that are currently being proposed (Oosterhaven et al. 2000). The design of this effort is such that each sub-problem is analyzed in such a way that the effects from other sub-studies are deliberately left out. Then, all effects can be added up in the end with the risk of double-counting. It is therefore that we have not discussed such matters as migration by workers, international repercussions and the environmental impact of the projects. This sub-study has been limited to the economic redistribution that is to be expected after each of the projects.

In the course of this study, a large model has been constructed from the ground up, in a limited time. Some shortcuts had to be taken here and there, leading to some matters not getting the attention that they probably deserved. The exogenous sector-specific parameters in appendix 6.A.3 were picked by experts after consulting data on the subject, but not estimated rigorously. Due to the non-linear character of the model, it is hard to quantify the effects that errors in these parameters can have.

Secondly, the concept of an endogenous number of firms had to be abandoned after the model turned out to be unstable. This leads to an underestimation of the effects of a new link: any effects that we find with a

⁷Estimates are based on 1995 GNP of 640.56 billion Dfl (CBS, Statline 2000).

fixed number of firms are sure to be larger when the variety-effect is taken into account.

However, this abandonment may be a blessing in disguise as it relieves us of another problem: during parameter estimation, the elasticity of substitution and the costs of transport were only weakly identified. With the results that we now present, these parameters operate together and need not have been estimated separately. A simulation involving the variety-effect would have used the elasticity of substitution intensively. Now, this elasticity is only used in conjunction with the costs of transport, except when the consumer price index is computed in section 6.4.3.

Thirdly, the use of *iceberg* transport costs, while theoretically convenient, leads to strange results here and there. For instance, a decrease in transport costs means that less product ‘melts’ along the way, which has a dampening effect on demand. This leads to an underestimation of the direct effects. The fact that one of our fourteen sectors is actually the transport sector makes matters even more awkward. A better way to include transport is the subject of further research.

6.6 Conclusion

We have constructed a spatial CGE model for 548 Dutch communities in 14 sectors, based on New Economic Geography principles. Our model can best be compared to the one in Bröcker (1999) and Venables and Gasiorek (1996) and uses intermediate products as in Venables (1996b). We calibrate the model to a base scenario for the year 2020 and use it to evaluate five infrastructural projects on which the Dutch government is about to decide.

We have chosen to model a demand-constrained labor market as if there is an infinite supply of labor available at a fixed wage. This leads to an instability in our model as the number of firms is derived from the amount of labor used. This problem is mitigated by assuming that the number of firms remains constant after a project has been implemented. Because of this, our results indicate mostly redistributive effects.

The most ambitious plan, called MZM in this paper (see appendix 6.A.2), leads to a shift of about 8,000 jobs. These jobs are gained in the North and the West, because of direct demand effects (each region’s products are cheaper for the other) and indirect effects: because of cheaper intermediate products prices go down. The same plan leads to a decrease in the consumer price index. While this decrease is felt mostly in the North, all consumers benefit. The welfare increase that is the result of this decrease in prices is equivalent to one obtained after raising GNP about 550 mln Dfl.

We have had to make a number of adaptations to the plain CGE model in order to get things to work properly. Sometimes, these adaptations are of an *ad hoc* nature and their effects on the are hard to gauge. Section 6.5

discusses the uncertainties that go along with this analysis.

Finally, the construction of this model can be seen as a first step toward the construction of a larger spatial CGE model of the Netherlands which can be used to help with infrastructural decisions in the future. TNO Inro and the University of Groningen are working on such a model at this time.

6.A Data and Conventions

6.A.1 Division of the Economy

In the Dutch economy, we identify fourteen sectors that produce goods and services. These goods and services are consumed by the public and demanded by other firms as intermediate products. The sectors are indexed by the variable s and are specified in Table 6.5.

Sector	Name	Sector	Name
1	Agriculture	8	Transport and Communications
2	Mining	9	Finance and Insurance
3	Industry	10	Other services incl. Real Estate
4	Public Utilities	11	Government
5	Construction	12	Education
6	Trade and Repairs	13	Health
7	Hotels, Restaurants, Bars	14	Culture and Recreation

Table 6.5: The fourteen different sectors in the economy

For each sector, we have used a number of coefficients concerning the use of different kinds of transport, tradeability and the nature of the exogenous ties to the location. These coefficients can be found in section 6.A.3.

Geographically, we divide the country into 14 major regions. The basis of this division are the twelve Dutch provinces. Ten of these are major regions, all except South Holland and North Holland which are each divided into two major regions: Metro Amsterdam including the area around the North Sea Canal is a major region, as is the rest of North Holland. Metro Rotterdam and the Ports is a major region, as is the rest of South Holland.

Each major region in turn consists of one or more COROP regions. There are 40 COROPs; the COROP division was originally intended to mark the size of local labor markets. Each COROP, finally, is divided into a number of communities. The model uses the 1998 situation regarding the municipal borders, leading to a total of 548 communities. The largest community is Amsterdam with 718,151 inhabitants, the smallest is the island of Schiermonnikoog with 1,003 inhabitants.

6.A.2 Available Data

IO Tables

Our most important source of data are the bi-regional input-output tables compiled in RuG/CBS (1999). Any reference to 'the IO tables' in this paper concerns this publication. The tables are available for twelve provinces and two metropolitan areas. Of each of these regions we know the internal 14x14 IO-table as well as external trade, summarized in two 14x14 IO tables (one for inputs from the rest of the country used and consumed locally and one for local outputs used and consumed in the rest of the country). From these tables, we derive not only the IO-structure on the regional level, but also flows of trade between the fourteen regions which help us estimate the model's parameters.

Community level data

We use the LISA (1998) database which gives, among other things, the amount of labor employed in each sector in each community in 1998. From this 548 by 14 matrix, we can derive production per sector per community and the number of firms per sector per community.

Distances

We discern two types of distance in this model. For goods transport, distance is measured in kilometers. We have computed the distance by car between all the possible pairs of communities using a CD ROM with travel information (AND 2000). This distance is used for goods transport in all scenarios, indicating that nothing changes with regard to this type of transport.

For passenger travel, we measure the distance between two communities in minutes. This distance is an average between the travel time by car (derived from AND (2000)) and by public transport. For the latter, we have a travel time matrix for detailing distances between any couple of communities for all scenarios (TNO 2000). This matrix is the one that changes most between scenarios, obviously. The weighing is done with *modal split* numbers supplied by the Netherlands Economic Institute (NEI 2000). For each scenario there is a modal split matrix for 28 areas, which takes into account the substitution effect that follows the construction of new infrastructure. This matrix is extrapolated to the 548x548 community pairs.

Scenarios

We use one economic scenario that is the basis for our calibration of the year 2020. This scenario gives the number of jobs in each sector in each

community in 2020 and the number of inhabitants in each community in the same year. It is compiled by TNO Inro (TNO 2000) and is based on the CPB's 'European Cooperation' scenario and a separate regional model used at TNO Inro. In principle, we could use the 2020 scenario as a test on our model, calibrating it on the 1990s data en checking whether the 2020 scenario leads to an economy in equilibrium at the community level. When we do this, we find that the scenario leads to a severe disequilibrium. When investigated more closely, it turns out that the problems arise because of developments incorporated in the scenario that cannot possibly be predicted by our model like a shift towards service industries.

There are six travel time scenarios. We give them in table 6.6 below, referring the reader to the main report (Oosterhaven *et al*, 2000) for a more detailed description. The table gives a brief description of the project as well as the projected travel time between the northern city of Groningen and Schiphol Airport in the West.

Scenario	Description	Groningen - Schiphol
REF	The null alternative. This includes the Hanzelijn between Lelystad and Zwolle, which is yet to be constructed.	118
HIC	Hanzelijn + IC. The only difference with REF is that trains will go at a higher speed.	102
HHS	Hanzelijn - high speed. A high-speed train replaces the intercity service on the HIC scenario, calling at the larger stations.	71
ZIC	Zuiderzeelijn IC. New track is constructed between Lelystad and Drachten, leading to a straight link between the North and the West. The track is serviced with intercity trains.	89
MZB	Magnetic track. A new technology is used to create super-high speed trains which travel from Groningen to Amsterdam in a straight line. All trains call at all major stations.	59
MZM	Magnetic track - metro schedule. As MZB, but with a schedule that has non-stop trains between only a few terminals.	45

Table 6.6: Six scenarios for travel time in 2020, each with a different infrastructural project completed

6.A.3 Other Coefficients

For each sector, we have supplied three coefficients exogenously to the model. These coefficients are given here.

The share of goods transport per sector π_s has been determined by outside experts using figures about transport costs from the available data on different sectors. They are given in the first column of table 6.7.

The tradeability of goods indicates the percentage of the output of a sector that can reasonably be expected to be available to customers outside the major region of production. For personal services like the proverbial haircut, tradeability is extremely low. Sector-wide figures are derived from IO data and sectorial indicators. It is given in the second column.

Finally, the degree to which a sector is exogenously tied to the present location is given in the third column. Exogenous ties result when the firm does not consider the price of inputs or its own price in the location decision. On the supply side, this happens when a firm uses specialized local inputs like natural resources or specialized labor, or a facility like a port. On the demand side, ties come about because of localized outputs, as for instance the local government sector can only supply its own citizens.

Sector	Share of goods transp. (π)	Tradeability	Exogenous ties
1 Agriculture	0.90	1.00	0.80
2 Mining	0.90	1.00	1.00
3 Industry	0.70	1.00	0.10
4 Public Utils	1.00	0.50	0.30
5 Construction	0.70	0.70	0.20
6 Trade & Repairs	0.30	0.50	0.30
7 Hotels etc.	1.00	0.50	0.50
8 Transport	0.70	0.75	0.30
9 Finance	0.00	0.70	0.30
10 Services	0.00	0.55	0.30
11 Government	0.10	0.45	1.00
12 Education	0.00	0.55	0.80
13 Health	0.10	0.45	0.80
14 Culture	0.10	0.55	0.50

Table 6.7: Exogenous coefficients for each sector

6.B Derivations

6.B.1 Costs and Production functions

When two factors are combined in the Cobb-Douglas production function $X^\alpha Y^{1-\alpha}$ and total costs $X \cdot p_X + Y \cdot p_Y$ are minimized, marginal costs are, up to a constant factor, equal to

$$p_X^\alpha \cdot p_Y^{1-\alpha}. \quad (6.14)$$

If you put the multiplicative constant in front of the production function, the marginal costs are exactly equal to (6.14). For this reason, c_{ps} and c'_{ps} are used. It is not hard to prove that they must be equal to

$$c_{ps} = (1 - \alpha_{ps})^{\alpha_{ps}-1} \cdot (\alpha_{ps})^{-\alpha_{ps}}$$

and

$$c'_{ps} = \prod_{s'=1}^{14} \gamma_{p,s,s'}^{-\gamma_{p,s,s'}}.$$

6.B.2 The number of firms

Proof. We want to proof that the number of firms of a certain sector s in a community c in province p is proportional to the amount of labor consumed by that sector in that community multiplied by that sector's local labor requirement α_{ps} . Exit and entry are free so that each firm makes zero profits. It follows that each firm operates on a scale where gross profits $Y \cdot MC / (\sigma_s - 1)$ are equal to a fixed startup cost F_s , which may differ per sector. From the equation for marginal costs, this implies that the optimal scale of firm j in sector s and region p , Y^* , is equal to

$$Y_{j,ps}^* = (\sigma_s - 1) \cdot F_s \cdot G_{c,s}^{\alpha_{ps}-1} \quad (6.15)$$

From production function (6.3) we derive the production of a firm as a function of the amount of labor used. It turns out that this is

$$\begin{aligned} Y_{j,ps} &= c_{ps} \cdot L_j \cdot \left(\frac{w}{G_{c,s}} \right)^{1-\alpha_{ps}} \cdot \left(\frac{1 - \alpha_{ps}}{\alpha_{ps}} \right)^{1-\alpha_{ps}} \\ &= \alpha_{ps} \cdot L_j \cdot G_{c,s}^{\alpha_{ps}-1} \end{aligned} \quad (6.16)$$

where we use $w = 1$ and the definition of c_{ps} . Equating (6.15) and (6.16) we find that a firm operating at optimal scale uses a fixed amount of labor, equal to

$$L^* = \frac{\sigma_s - 1}{\alpha_{ps}} F_s.$$

Because the amount of labor consumed in community c by sector s , $L_{c,s}^{total}$, is equal to

$$L_{c,s}^{total} = n_{cs} \cdot L^* \quad (6.17)$$

we find that the number of firms n_{cs} varies proportionally to the product of $L_{c,s}^{total}$ and α_{ps} . ■

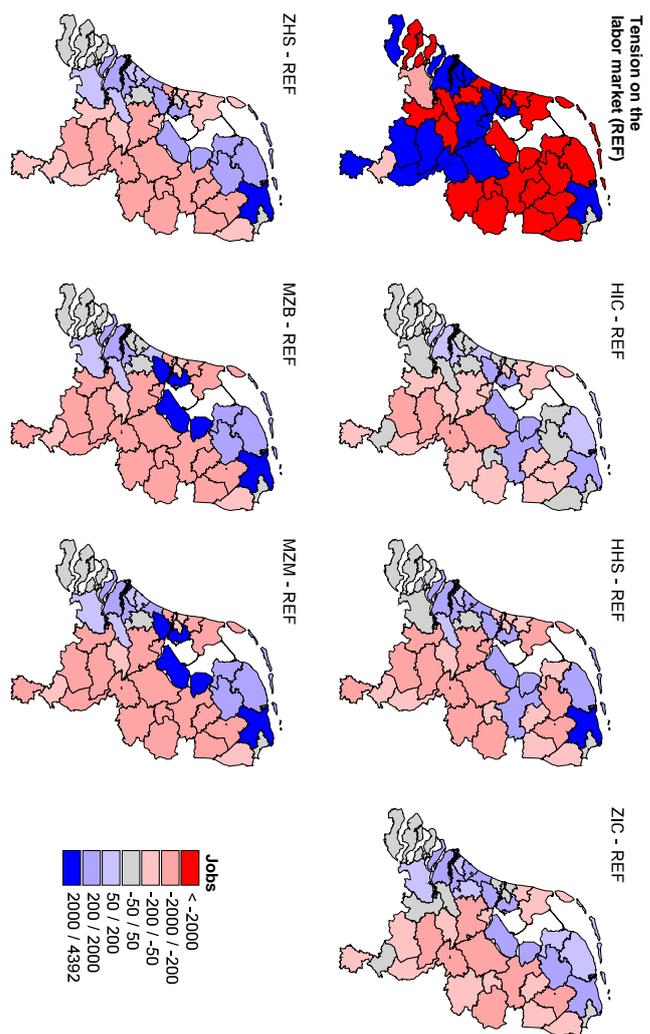


Figure 6.2: The effect of the six scenarios on the number of jobs in each COROP region.